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A Quarterly Journal of Entomological Research

ENTOMON

Entomon is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September and December, devoted to publication of research work on various aspects of insects and other land arthropods.

Address MS and all editorial correspondence to Managing Editor, *Entomon*, Department of Zoology, University of Kerala, Kariavatto.n, Trivandrum, India 695 581.

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Annual Subscription for institutions: Rs 150/- (in India); $ 50/- (abroad, air mail)
" " individuals: Rs 50/- ,, ; $ 20/- (,, sea mail)

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INTRA–TREE SPATIAL DISTRIBUTION OF EGGS AND EGG COLONIES OF *ALEUROCANTHUS WOGLUMI* ASHBY (HOMOPTERA : ALEURODIDAE) ON LIME

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The studies on intra-tree spatial distribution of eggs and egg colonies of citrus blackfly, *Aleurocanthus woglumii* Ashby were conducted on lime (*Citrus aurantifolia* Swing.) trees at Indian Institute of Horticuitural Research, Hessaraghatta, Bangalore. The important statistical parameters of distribution viz., mean density ($\overline{x}$), variance (s^2), variance mean ratio, mean crowding (X^*), exponent-K and Lloyd's index of patchiness revealed that eggs and egg colonies of *A. woglumi* followed a negative binomial intra-tree distribution. The goodness of fit was tested by chi-square test. Further, Arbous and Kerrich's (1951) mean clump (λ) size explained that the cause of aggregation of eggs is the inherent ovipositional behaviour of the female black flies while aggregation of egg colonies is due to the heterogeneity of the ovipositional habitat.

(Key words: Intra-tree spatial distribution, mean crowding, mean clump size, Lloyd's index of patchiness, *Aleurocanthus woglumi)*

INTRODUCTION

The citrus blackfly, *Aleurocanthus woglumi* Ashby is considered a potential threat to citrus crop wherever it is grown (DIETZ & ZETEK, 1920; HUTSON, 1922; PRUTHI & MANI, 1945; HOWARD & NEEL, 1977). It was first reported by Lefroy in 1910 (PRUTHI & MANI, 1945) from India and since then it has spread to several countries like Argentina, Bahama Island, Bermuda, Cayman Islands, Columbia, Costa Rico, Cuba, Dominican Republic, El Salvador, Eucador, Haiti, Jamaica, Mexico, Nicaragua, Panama, U S A and Venezuela (DOWELL *et al.*, 1981). In India, in the recent past, excessive use of broad spectrum insecticides has disrupted the orchard ecosystem by eliminating the natural enemies and has thus resulted in the outbreak of this pest, particularly in Nagpur area of Maharashtra State.

For the effective management of *A. woglumi*, it is necessary to have a complete understanding of the population dynamics and obviously knowledge of spatial distribution is the first important step towards that. It is in this context that the present studies on intra–tree spatial distribution of eggs and egg colonies of *A. woglumi* were conducted on lime which is one of the major host plants.

MATERIALS AND METHDOS

The studies on intra–tree spatial distribution of citrus blackfly (*A. woglumi* Ashby) eggs and egg colonies were conducted on ten severely infested lime (*Citrus aurantifolia*

Swing.) trees of 7–8 years old at Horticultural Experimental Station of Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, during 1982. These trees were kept free of insecticidal sprays during the period under study. From each tree, 25 leaves were taken from terminal shoots which were selected from all the directions and canopy heights. These leaf samples were brought to laboratory in brown paper bags and observations were recorded on egg colonies and number of eggs in each colony under dissecting microscope. The first observation was recorded on 10th June, 1982 and subsequent two observations were recorded at fortnightly interval.

The data were initially subjected to the analysis of dispersion indices viz., variance mean ratio $(s^2/\bar{x})$, mean crowding (X^*) and LLOYD's (1967) index of patchiness $(X^*/\bar{X})$. The value of mean crowding (X^*) with estimates based on samples was estimated by the formula given as below:

$$X^* = \bar{x} + \frac{s^2}{\bar{x}} - 1$$

where $\bar{x}$ = mean and s^2 = variance.

The LLOYD's (1967) index of patchiness was calculated by dividing mean crowding values with their respective mean density values. The value of index equals to unity in random distribution, while greater or smaller values than unity is contagious or regular distributions, respectively.

Finally, the data were subjected to the analysis of negative binomial distribution and exponent-K was worked out. The distribution was tested for goodness of fit by chi–square test on observed and expected values and probability of fit was calculated. Further, the cause of aggregation was ascertained by estimating Arbous and KERRICH's (1951) mean clump size (λ) by the following formula:

$$\lambda = \frac{\bar{X}}{2\,K}\ \ V$$

where $\bar{x}$ = mean, K = dispersion parameter for negative binomial and V is a function with chi–square distribution with 2 K degree of freedom.

RESULTS AND DISCUSSION

1. Intra–tree spatial distribution of eggs: The data on different statistical parameters of intra–tree spatial distribution of eggs viz., mean density $(\bar{X})$, variance (s^2), variance mean ratio $(s^2/\bar{X})$, mean crowding (X^*) LLOYD's (1967) index of patchiness $(X^*/\bar{X})$, dispersion parameter-K, chi–square, probability of fit and ARBOUS & KERRICH's (1951) mean clump size are presented in Tables 1—3.

In the first observation (Table 1), the values of variance mean ratio which ranged between 2.29 to 8.69 indicated the departure of distribution from randomness to clumping. This was further supported by the values of index of mean crowding and Lloyd's index of patchiness. All the values of mean crowding index exceeded their respective mean density values. Similarly the values of Lloyd's index of patchiness being greater than one indicate aggregation of eggs. The exponent-K varied from 0.85 to 8.74 in different sets of data. Except set No. 9, in all other sets, the K–value was less than 8 which confirmed the contagious nature of distribution of eggs on the leaves. The probability of fit for negative binomial distribution as tested by chi–square statistics ranged between 0.35 to 0.85 which was quite high for natural field population. The mean clump size (λ) exceeded 2 in 90 percent cases which indicated that cause of aggregation of eggs could be either ovipositional behaviour of the pest or environment heterogeneity. However, in this case it is due to ovipositional behaviour of the *A. woglumi* females which lay eggs in spiral rings on the ventral side of a leaf.

The data of the second observation on intra–tree spatial distribution of *A.*

TABLE 1. Intra-tree spatial distributione of *A. woglumi* eggs on lime (10–6–82).

S. no.	mean ($\overline{X}$)	variance (s^2)	$s^2/\overline{X}$	expon-ent—K	mean crow-ding (X^*)	Lloyd's index of patchi-ness	chisquare value	probabi-lity of fit	λ
1	2.16	7.64	3.54	0.85	4.70	2.17	1.19	0.58	1.40
2	15.96	92.95	5.83	3.31	20.78	1.30	3.68	0.60	14.36
3	15.72	96.87	6.16	3.05	20.88	1.33	0.63	0.72	14.03
4	15.20	132.17	8.69	1.98	22.89	1.50	0.41	0.81	12.73
5	20.82	122.81	5.89	4.25	25.71	1.24	11.46	0.55	19.21
6	14.25	102.41	7.19	2.30	20.44	1.43	3.03	0.85	12.24
7	17.23	64.48	3.74	6.28	19.96	1.16	13.68	0.55	16.32
8	19.42	101.69	5.23	4.58	23.66	1.22	8.15	0.35	18.02
9	19.36	62.24	3.21	8.74	21.57	1.11	0.70	0.85	18.56
10	4.80	11.00	2.29	3.72	6.09	1.27	2.94	0.35	4.37

TABLE 2. Intra-tree special distribution of *A. woglumi* eggs on lime (25-6-1982).

S. no.	mean ($\overline{X}$)	variance (s^2)	$s^2/\overline{X}$	expon-ent—K	mean crow-ding (X^*)	Lloyd's index of patchi-ness	chisquare value	probabi-lity of fit	λ
1	9.59	122.80	12.80	0.81	21.40	2.23	4.63	0.10	6.11
2	19.94	118.97	5.97	4.02	24.91	1.24	14.37	0.12	18.30
3	19.51	86.43	4.23	5.69	22.94	1.18	6.79	0.60	18.33
4	18.57	71.63	3.86	6.50	21.43	1.15	7.63	0.45	17.62
5	22.40	141.00	6.29	4.23	27.69	1.24	4.44	0.25	20.66
6	19.85	123.80	6.23	3.79	25.08	1.26	10.32	0.18	18.13
7	20.68	110.45	5.34	4.76	25.02	1.20	3.57	0.75	19.25
8	20.63	81.96	3.97	6.94	23.59	1.14	14.80	0.16	19.62
9	18.44	107.48	5.83	3.82	23.27	1.26	5.22	0.55	17.09
10	11.41	103.09	9.03	1.42	19.45	1.70	6.27	0.10	8.87

woglumi eggs presented in Table 2, exhibited a pattern of distribution similar to the first observation. The variance mean ratio exceeded one in all the ten sets of data which revealed over dispersion of egg population. The values of mean crowding index being higher than their respective mean density values, indicated the contagious nature of distribution. The Lloyd's index of patchiness exceeded one in all the cases and thereby supported the conclusion about the aggregation of eggs. Similarly, the dispersion parameter (K) values which ranged between 0.81 and 6.94, further confirmed clumping of eggs. The probability of fit ranged between 0.10 and 0.75 which was quite substantial. The mean clump size (λ) varied from 6 11 to 20.66 and thus revealed the cause of aggregation as ovipositional behaviour of female blackflies.

The results of third observation presented in the Table 3 showed trend similar to previous two observations. The variance mean ratio being uniformly higher than one in all the sets of data, clearly indicated over-dispersion of egg population. This was further amply reflected by mean crowding index, Lloyd's index of patchinees and dispersion parameter–K. However, the values of probability of fit were low in comparison to previous observations. Among various contagious distribution models hitherto proposed, the negative binomial has proved to be most widely applicable (BLISS, 1958; BLISS & OWEN, 1958; WATERS, 1959; SHUKLA *et al.*, 1985). The aggregation of eggs resulted due to inherent ovipositional behaviour of female citrus blackflies as shown by ARBOUS & KERRICH'S mean clump size which exceeded two in all the sets of data.

2. *Intra-tree spatial distribution of egg colonies:* The data on various statistical parametrs of intratree spatial distribution of egg colonies of *A. woglumi*

TABLE 3. Intra-tree special distribution of *A. woglumi* eggs on lime (4–7–1982).

S. no.	mean ($\overline{X}$)	variance (s^2)	$s^2 / \overline{X}$	exponent—K	mean crowding ($X^\bullet$)	Lloyd's index of patchiness	chisquare value	probability of fit	λ
1	9.56	118.31	12.38	0.84	20.94	2.19	4.59	0.22	6.19
2	17.96	90.25	5.02	4.47	21.99	1.22	14.69	0.08	16.64
3	13.20	85.88	6.51	2.40	18.70	1.41	8.24	0.32	11.41
4	13.63	110.36	8.10	1.92	20.73	1.52	8.77	0.12	11.35
5	19.31	133.46	6.91	3.27	25.22	1.31	12.39	0.08	17.38
6	12.34	121.83	9.87	1.39	21.21	1.72	4.61	0.20	9.54
7	17.82	111.87	6.28	3.37	23.09	1.30	10.33	0.12	16.09
8	18.94	117.15	6.19	3.65	24.13	1.27	6.74	0.25	17.24
9	12.83	133.09	10.37	1.37	22.20	1.73	7.68	0.10	9.88
10	9.62	114.30	11.87	0.89	20.50	2.13	4.03	0.26	6.38

TABLE 4. Intra-tree spacial distribution of *A. woglumi* egg colonies on lime (10-6-1982).

S. no.	mean ($\overline{X}$)	variance (s^2)	$s^2/\overline{X}$	expon-ent—K	mean crow-ding (X^*)	Lloyd's index of patchi-ness	chisquare value	probabi-lity of fit	λ
1	0.76	1.02	1.35	2.19	1.11	1.46	0.15	0.70	0.62
2	2.16	4.14	1.92	2.36	3.07	1.42	1.36	0.76	1.86
3	4.42	27.21	6.16	0.86	9.58	2.17	1.88	0.60	2.82
4	4.04	14.46	3.58	1.56	6.62	1.64	0.91	0.80	3.22
5	18.08	62.92	3.35	8.01	21.15	1.12	1.14	1.75	17.52
6	3.60	24.66	6.85	0.62	9.45	2.63	0.69	0.70	1.97
7	4.64	48.24	10.40	0.49	14.03	3.03	0.84	0.85	2.11
8	3.64	24.57	6.75	0.63	9.39	2.58	0.51	0.75	2.01
9	1.52	6.18	4.06	0.50	4.58	3.01	0.43	0.80	0.69
10	1.84	6.97	3.79	0.66	4.63	2.52	0.07	0.90	1.05

namely mean density ($\overline{X}$), variance (s^2), variance mean ratio ($s^2/\overline{X}$), mean crowding (X^*), Lloyd's index of patchiness, dispersion parameter–K, chi–square, probability of fit and Arbous and KERRICH'S (1951) mean clump size are presented in Table 4—6.

In the first observation in all the ten sets of data (Table 4), variance values exceeded their respective mean densities which indicated the contagious nature of intra-tree distribution of egg colonies of *A. woglumi*. In general variance values increased with increase in mean densities. This relationship between variance and mean density has been reported in the past (TAYLOR, 1961; HARCOURT, 1963; SHUKLA *et al.*, 1985). The values of mean crowding index indicated over–dispersion of egg colonies. Similarly, the values of Lloyd's index of patchiness which ranged between 1.57 and 2.89, supported the conclusion about aggregation of egg colonies. The chi–square test indicated

good agreement between observed and expected frequencies. The probability of fit for negative binomial distribution ranged between 0.6 and 0.9 which was quite good. The ARBOUS & KERRICH'S mean clump size ranged between 0.62 and 17.92. In five sets of data where aggregation of less than 2 mean clump size of colonies of *A. woglumi* was noticed, the cause of aggregation could be the environmental heterogeneity while in other, five sets where the aggregation of more than two mean clump size of colonies have been observed, the cause of aggregation can be attributed to either environmental heterogeneity or genetic behaviour of the species (BLACKITH, 1958). However keeping in view the behaviour of the female blackflies which lay eggs only on new yellowish green leaves, it can be concluded that aggregation of egg colonies is due to heterogeneity of the ovipositional habitat.

The results of the second observation on intra–tree spatial distribution of egg

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TABLE 5. Intra-tree spatial distribution of *A. woglumi* egg colonies on lime (25-6-1982).

S. no.	mean ($\overline{X}$)	variance (s^2)	$s^2 / \overline{X}$	expon-ent —K	mean crow-ding (X^*)	Lloyd's index of patchi-ness	chisquare value	probabi-lity of fit	λ
1	0.80	1.25	1.56	1.42	1.36	1.70	0.90	0.75	0.78
2	1.52	5.59	3.68	0.57	4.20	2.76	0.03	0.98	0.78
3	3.68	13.23	3.59	1.42	6.27	1.70	0.20	0.90	3.60
4	1.16	3.56	3.06	0.56	3.23	2.78	0.27	0.77	0.59
5	12.32	30.06	24.35	0.53	35.67	2.89	0.14	0.90	7.38
6	1.00	2.33	2.33	0.75	2.33	2.33	0.25	0.88	0.61
7	3.36	11.91	3.54	1.32	5.90	1.76	0.47	0.78	2.56
8	3.48	17.51	5.03	0.86	7.51	2.16	1.11	0.75	2.23
9	3.52	26.67	7.57	0.53	10.09	2.87	0.76	0.68	1.68
10	3.36	9.82	2.92	1.75	5.28	1.57	1·01	0.60	2.75

TABLE 6. Intra-tree spatial distribution of *A. woglumi* egg colonies on line (4-7-1982).

S. no.	mean ($\overline{X}$)	variance (s^2)	$s^2 / \overline{X}$	expon-ent —K	mean crow-ding (X^*)	Lloyd's index of patchi-ness	chisquare value	probabi-lity of fit	λ
1	0.84	4.31	5.12	0.20	4.97	5.91	0.17	0.69	0.95
2	1.12	5.44	4.86	0.29	4.98	4.44	0.25	0.65	0.51
3	2.12	6.94	3.28	0.93	4.40	2.07	2.43	0.48	1.43
4	1.52	6.26	4.11	0.49	4.64	3.05	0.15	0.92	0.69
5	2.68	15.81	5.10	0.55	7.58	2.83	0.43	0.80	1.33
6	2.16	7.89	3.65	0.81	4.81	2.23	2.60	0.48	1.37
7	2.28	8.54	3.75	0.82	5.03	2.20	1.70	0.60	1.46
8	2.04	8.54	4.19	0.64	5.23	2.56	0.21	0.90	1.14
9	1.44	5.26	3.65	0.54	4.09	2.84	0.57	0.75	0.70
10	1.20	4.33	3 61	0.46	3.81	3.17	3.32	0.07	0.55

colonies are presented in Table 5. The perusal of the data on various indices of dispersion viz., variance mean ratio, mean crowding, Lloyd's index of patchiness and K-value revealed high degree of aggregation of egg colonies of *A. woglumi* on lime leaves. The probability of fit for negative binomial distribution varied from 0.60 to 0.98 which was quite high. The values of ARBOUS & KERRICH'S mean clump size ranged between 0.61 and 7.38 which indicated environmental heterogeneity as the cause of aggregation. However, in general, mean clump size of egg colonies decreased in comparison to first observation taken 15 days before which is apparently due to decrease in mean density.

The data of the third observation (Table 4) indicated similar trend in the distribution of egg colonies. However, a reduction in the mean density of egg colonies was apparent and it further influenced the K and mean clump size values. This kind of relationship between mean density and dispersion parameter-K has been reported earlier by various workers (ANSCOMBE, 1949; BLISS & FISHER, 1953; LEGAY, 1963). The K-values which ranged between 0.20 and 0.92, supported the aggregating nature of egg colonies. Except for set No. 10, in all other cases the probability of fit for negative binomial distribution varied from 0.48 to 0.92. The ARBOUS & KERRICH'S mean clump was less than two in all the sets of data which revealed the heterogeneity of ovipositional habitat and high population density of female blackflies in relation to availability of suitable ovipositional sites as causes of aggregation of egg colonies.

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EFFECT OF SOWING DATE MANIPULATIONS OF COMMON MILLET CULTIVARS ON SHOOT FLY (*ATHERIGONA* SPP·) INCIDENCE IN NORTH BIHAR

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Periodical sowings of four common millet (*Panicum miliaceum* L) varieties, *viz.*, BR 7, MS 4872, MP 29 and BR 9 were done at fortnightly intervals starting from 15th February, 1980 to study the incidence of shoot fly (*Atherigona* spp.)· The crops sown on 15th February and 1st March experienced heavy loss at seedling stage while those sown between 15th March to 1st April experienced least damage· The fly, however, maintained its sustained activity throughout the year. BR 7 out-yielded (13.12 q/ha) the other varieties followed by BR 9 (12.7 q/ha).

(Key Words: sowing date, common millet, *Atherigona* spp)

INTRODUCTION

Among the minor millets, common millet *(Panicum miliaceum* L) occupies a pivotal position in crop husbandry particularly in rainfed areas of Uttar Pradesh and Bihar either as seasonal or catch crop. The crop, however, is subject to severe attack of shoot fly *(Atherigona* spp.) and poses a limiting factor in its cultivation. The fly attacks the plants in very early stage when they are about ten days old. The older plants are comparatively less prone to shoot fly attack. Under such circumstances, sowing of the crop at a time which can avoid the critical period of the pest activity without any adverse effect on growth and yield appears to be sound approach to combat this pest. No published record is available on this aspect from Bihar. The present investigations were, therefore, undertaken to study the effect of varying dates of sowing of common millet cultivars on the incidence of the fly as well as on yield with the object of obtaining the maximum return.

MATERIALS AND METHODS

A field trial was conducted at Tirhut College of Agriculture, Dholi in split plot design during summer, 1980 with four common millet varieties *viz.*, BR 7, BR 9, MP 29 and MS 4872 sown on five different dates at fortnightly intervals starting from 15th February with a view to obviate the critical period of the fly *(Atherigona* spp.) activity. There were altogether twenty treatments and each treatment was replicated thrice with the mains and subs at 7.9×5.0 and 5.6×1.6 metre, respectively. The row to row and plant to plant distance were kept 22.5 and 10 cm, respectively. Fertilizers were applied @ N: P: K = 40: 20: 20. Observations pertaining to percentage damage due to the fly were recorded on the basis of 'deadheart' and 'white earhead' formation, 4 weeks after sowing and 3 weeks after panicle initiation stage, respectively. The yield data along with the meteorological parameters were also recorded. The data were subjected to statistical analysis and the results are presented in Tables 1 and 2.

TABLE 1. Effect of sowing days on the incidence of shoot fly., *Atherigona* spp. to different cultivars of common millets.

Sowing date	percentage of deadheart (28 DAS)					percentage of white earhead (21 DAPIS)					mete. tem. 0C	obesr. RH %
	BR 7	MP 29	MS 4872	BR 9	mean	BR 7	MP 29	MS 4872	BR 9	mean		
15th Feb. '80	54.4 (45.54)	45.2 (42.24)	55.3 (48.00)	44.1 (41.63)	48.9 (44.35)	7.5 (15.81)	8.8 (17.21)	7.3 (15.63)	10.1 (18.55)	8.4 (16.80)	20± 8	85±15
1st Mar. '80	38.8 (38.55)	45.6 (42.49)	33.2 (35.17)	38.9 (38.55)	39.1 (39.69)	12.9 (21.07)	16.00 (23.58)	14.3 (22.23)	14.8 (22.65)	14.5 (22.38)	23± 9	93± 7
15th Mar. '80	25.2 (30.15)	16.1 (23.16)	14.9 (22.74)	16.1 (23.16)	17.9 (25.03)	10.5 (18.95)	14.7 (22.54)	13.1 (21.44)	11.9 (20.12)	12.5 (20.71)	26± 9	76±19
1st April '80	14.0 (21.99)	16.6 (24.02)	12.0 (20.26)	12.0 (20.26)	13.6 (21.26)	26.6 (31.12)	16.7 (24.14)	23.2 (28.74)	23.3 (28.84)	22.4 (28.21)	28± 8	58±15
15th April '80	24.6 (29.72)	22.0 (27.98)	25.3 (30.19)	31.3 (34.00)	25.7 (30.47)	25.0 (29.99)	30.0 (33.20)	29.5 (32.86)	38.4 (38.22)	30.6 (33.58)	30±10	60±16
Mean	33.0 (33.19)	28.2 (32.07)	27.0 (31.27)	27.5 (31.60)	28.1 (32.03)	15.8 (23.39)	16.7 (24.13)	16.7 (24.14)	18.8 (25.68)	17.0 (24.34)	25± 8	74±14

SE/plot	(Main)	2.69
SE/plot	(Sub)	2.36
SE/Mean	(Date)	0.77
SEm	(var.)	0.61
SEm	(D × V)	1.36
CD at 5%	(Date)	2.22
CD at 5%	(D × V)	3.92

SE/plot	(Main)	1.86
SE/plot	(Sub)	2.20
SE/Mean	(Date)	0.63
SEm	(var.)	0.57
SEm	(D × V)	1.27
CD at 5%	(Date)	1.82
CD at 5%	(D × V)	3.66

DAS : Days after sowing. DAPIS : Days after panicle initiation stage (Figures in the parentheses are arc sin √Percentage values.

TABLE 2. Effect of sowing dates on mean yield of different common millent cultivars.

| Sowing date | yield in quintal per hectare | | | | main |
	BR 7	MP 29	MS 4872	BR 9	
15th February '80	7.08	5.62	5.42	5.62	5.93
1st March '80	10.41	10.00	10.21	9.79	10.10
15th March '80	13.12	8.95	12.08	12.71	11.72
1st April '80	12.49	8.12	8.33	9.08	9.51
15th April '80	9.16	7.79	8.87	8.77	8.97

SE/plot (Main)	2.24		SE/Mean (D × V)	1.19
SE/plot (Sub)	2.06		CD at 5% (Date)	1.87
SE/mean (Date)	0.65		CD at 5% (Variety)	1.53
SE/mean (Variety)	0.53		CD at 5% (D × V)	3.43

RESULTS AND DISCUSSION

The percentage 'deadheart' due to shoot fly was the minimum (13.6%) when the varieties were sown on 1st April while the maximum (48.9%) when sown on 15th February. Sowing on 15th March resulted in 17.0 per cent 'deadheart's (Table 1). The data also showed variations in the formation of 'white earhead'. The varieties sown on 15th February gave the minimum 'white earhead' formation (8.4%) while the maximum when planted on 15th April (30.6%). The maximum activity of the fly thus occurred when the ambient temperature and relative humidity ranged from $20 \pm 8°C$ and $23 \pm 9°C$ and $85 \pm 15\%$ to $93 \pm 7\%$ R H, respectively. SUBBIAH & IBRAHIM (1967) and JOIWANI et al., (1970) obtained similar relationship while working on the seasonal incidence of the fly on sorghum and jowar, respectively.

SANTHARAM & VENUGOPAL (1978) reported significant and positive correlation of the fly incidence on P. miliaceum with low temperature and high humidity. The amblent temperatures higher than $23 \pm 9°C$ accompanied with relative humidities less than $93 \pm 7\%$ R H prevailing from the second half of March onward seemed to have adversely affected the fly activity on P. miliaceum in north Bihar conditions. PANDEY et al. (1977) reported the adverse effect of high temperatures on the egg laying of Atherigona spp. on sorghum and maize, respectively, irrespective of the varieties involved. This appears to hold good in this case also.

The data in Table 2 revealed tha the varieties gave significant increase in yield when sown on 15th March excepting MS 29. BR 7 out-yielded all the varieties (13.12 q/ha) followed by BR 9 (12.71 q/ha).

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BRIEF COMMUNICATION

INSECTICIDAL CONTROL OF MELON APHID, *APHIS GOSSYPII* GLOVER ON MUSK MELON

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Relative efficacy of nine insecticides was evaluated against melon aphid infesting musk melon in semi-arid region of Rajasthan. The results indicated that two sprays of 0.03% dimethoate, 0.20% carbaryl, 0.07% endosulfan and 0.035% phosalone at 15 days interval after 20 days of sowing gave significant protection to the crop against the pest. *(Key Words:* insecticidal control, melon aphid)

Melon aphid, *Aphis gossypii* Glover is a polyphagous pest and causes extensive damage to cucurbitaceous crops. Both nymph and adult suck sap from the underside of leaves and apical shoots resulting in stunting of plants, curling of leaves and reduction in yield (Mohanasundarum & David, 1972). Coudriet (1962) reported that the insect acts as a vector transmitting water melon mosaic in melons. Number of insecticides have been recommended against this pest damaging different crops, but no work has been done on cucurbits. Therefore, the efficacy of some newer insecticides was evaluated against the melon aphid infesting musk melon in semi–arid region of Rajasthan.

An experiment was laid out in a randomised block design during *ziad* (March–June) of 1980 and 1981 at the Horticulture farm, College of Agriculture, Jobner. The seeds of musk melon (var. 'Durgapura madhu') were sown by dibbling, 0.5 m apart on both the sides of

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0.7 m wide irrigation channel in plots of 5 × 4 m. There were nine insecticidal treatments (Table 1) besides control, each replicated thrice. The insecticides were sprayed twice on the crop on the appearance of aphid infestation after 20 days of sowing at 15 days interval. The efficacy of the insecticides was evaluated on the basis of pest population recorded on 5 tagged plants from each plot, a day before and 3, 7 and 15 days after each treatment. The pest population data thus obtained were pooled together and subjected to analysis of variance after $\sqrt{n + 0.5}$ transformation.

The data of two years indicate that all the insecticides reduced the population of aphid significantly. However, dimethoate proved best followed by carbaryl, endosulfan and phosalone upto 15 days (Table 1). Toxaphene and dicofol were found least effective insecticide. The present findings are in agreement with those of Reghupathy & Jayaraj (1973), Satpathy (1973) and Pareek & Noor (1979) who had reported the spray of 0.03 per cent dimethoate for the control of *A. gossypii* infesting brinjal and potato. Simultaneously, recommendations of

TABLE 1. Efficacy of insecticides against melon aphid on musk melon.

| S. no. | Treatments | Conc. (%) | No. of spray | Mean aphid population/plant* (Days after treatment) | | | | | |
| | | | | 1980 | | | 1981 | | |
				3	7	15	3	7	15
1	Chlorpyriphos 20 EC	0.05	2	36.00 (6.04)	34.67 (5.80)	113.67 (8.61)	20.17 (4.35)	31.00 (5.59)	92.50 (8.69)
2	Ethion 50 EC	0.05	2	69.67 (8.38)	70.17 (8.02)	138.33 (9.54)	40.83 (6.31)	45.00 (6.74)	105.50 (9.51)
3	Phosalone 35 EC	0.035	2	27.67 (5.31)	34.50 (5.71)	101.00 (8.04)	17.50 (3.97)	25.00 (4.99)	82.33 (7.97)
4	Dicofol 18.5 EC	0.10	2	75.50 (8.69)	108.17 (10.15)	143.67 (9.73)	46.00 (6.48)	87.33 (9.28)	143.83 (11.40)
5	Carbaryl 50 WP	0.20	2	15.67 (3.92)	21.00 (4.59)	90.33 (7.08)	8.33 (2.84)	15.50 (3.96)	59.00 (6.67)
6	Toxaphene 80 EC	0.10	2	79.17 (8.76)	117.17 (10.57)	150.67 (9.85)	45.17 (6.52)	78.17 (8.78)	128.00 (10.65)
7	Malathion 50 EC	0.05	2	69.00 (8.18)	119.50 (9.20)	198.50 (11.19)	29.83 (5.34)	41.50 (6.47)	113.00 (9.92)
8	Endosulfan 35 EC	0.07	2	23.50 (4.86)	22.17 (4.68)	105.16 (7.61)	12.67 (4.73)	22.83 (4.77)	78.33 (7.64)
9	Dimethoate 30 EC	0.03	2	11.67 (3.44)	12.00 (3.41)	53.67 (5.55)	4.34 (2.18)	7.17 (2.69)	23.17 (3.93)
10	Control	—	2	208.50 (14.44)	194.50 (13.46)	223.67 (11.84)	201.50 (13.87)	196.17 (14.02)	177.17 (13.04)
	CD (P = 0.05)			(0.26)	(0.29)	(0.32)	(0.29)	(0.32)	(0.23)

* Average of 15 plants. Figures in parentheses are $\sqrt{n + 0.5}$ transformation values.

carbaryl (PATEL & PATEL, 1966; JOSHI & SHARMA, 1973) and endosulfan (SRIVASTAVA *et al.*, 1972; BUTANI & VERMA, 1976) for the control of this aphid supports the present findings. The treatments of chlorpyriphos, ethion and malathion ranked in middle order of effectiveness.

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BIONOMICS AND SOME BEHAVIOURAL ASPECTS OF THE MANGO STONE WEEVIL, *STERNOCHETUS GRAVIS* (FABRICIUS) (COLEOPTERA : CURCULIONIDAE)*

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Sternochetus gravis (Fabricius) occurred as a serious pest of mangoes and was distributed throughout Tripura, a State adjoining Bangladesh. The life-history of the weevil was studied on *Mangifera indica* fruits at different temperatures in the laboratory at Agartala during 1982—1984. The reproductively immature adults overwintered inside seeds or other protective places during May-February. The females outlived the males and the survival period varied from 82.2 to 135 days. Provision of food significantly increased the longevity of females only. The weevils undertook short flights only along a horizontal plane. The ratio of males to females was approximately 1:1.4. Mating occurred 10 to 15 days after termination of hibernation and lasted 19 to 22 minutes. Oviposition occurred from March to May on immature mango fruits. No other material was found suitable for successful hatching of eggs. Eggs were laid singly on the surface of fruits. The process of egg laying was quite peculiar. The mean egg size was 0.6 mm in length. Eggs hatched after 4 to 6 5 days and the larvae fed on cotyledons or pulp. They underwent five identifiable instars. Pupation occurred in mango flesh and seed and occupied 7 to 10 days. Larval maturity was influenced more by different temperature regimens than other stages. One complete life-cycle occupied on an average 41.2, 41.6 and 48.3 days at $22 \pm 3°C$, $24 \pm 3°C$ and $27 \pm 2°C$ respectively. The species was univoltine. A new host of the pest species, *M. sylvatica* was recorded. Three species of ants, *viz., Oecopylla smaragdina, Camponotus* sp. and *Monomorium* sp. were predators and fungus *Aspergillus* sp. and mite *Rhizoglyphus* sp. ectoparasitised the larvae, pupae and hibernating adults.

(Key words: *Sternochetus gravis* (F.), biology, mango, Tripura)

INTRODUCTION

A thorough study of the biology of the pest may provide information with regard to vulnerable stages in the life-cycle at which the pest could be economically and effectively controlled, causing minimum disturbance to the ecosystem. Of three species of mango nut weevils which are causing economic damage, *Sternochetus mangiferae* (Fabricius) has a worldwide distribution and some information on the ecology and behaviour is available (BALOCK & KOZUMA, 1964). Practically no information on these aspects is available with regard to *S. frigidus* (F.) which is found in some areas of Bangladesh (ALAM, 1962), and *S. gravis* (F.) which is causing serious economic damage to mangoes in North-East India (PANDE & DEY, 1985).

The present study on the biology, life-history and behaviour of the pest

and the effect of three different tempera-
ture regimens on the development of the
nut weevil, S *gravis* in Tripura was
undertaken because of the seriousness of
the infestation (65 to 100%), meagre
knowledge on its management and the
pest being an impediment to mango
export.

MATERIALS AND METHDOS

Hosts and distribution : State–wide regular
surveys, twice in each mangoseason, from 1982
to 1984 to detect areas infested by the pest
species. Intensity of attack was also recorded.

Biology, life-history and behaviour: Infested
mangoes were collected from orchards and local
market and kept inside cages for recording the
hibernation period and the time of emergence
of adults. Several other fruits, *viz., Mangifera
sylvatica,* cashewnut, *Rhus parviflora,* apple,
litchi and also potato were offered to find out
the preferred site for oviposition and to test
them as alternate hosts. The longevity and
survival of adults were recorded under fed
and unfed conditions (Table 1).

In a glass cage fresh mango twigs with
fruits were kept to study the mating behaviour,
frequency of mating and copulation period.
Details of oviposition were recorded by examining
fruits under binocular microscope. Egg laying
period, fecundity, percentage of hatch and
rate of egg laying were recorded by releasing
four healthy and active copulated females.

The larval and pupal stages, using 10 in-
sects in each set, were studied in the labora-
tory by rearing them in the cavities made in
the mango fruits. Duration of life stages
under temperature prevailing during March—
April, April—May and May—June were recor-
ded The different larval forms were collected
and preserved for measuring the width of the
head capsule with an ocular micrometer and
to determine the instars.

A large number of collected mangoes were
cut open during mango fruiting season to
record pest population and natural enemies.

RESULTS AND DISCUSSION

Host and Distribution

Despite the great economic import-
ance of *S. gravis,* no information on its

distribution in Tripura has been published;
the pest had not even been recorded.
The present State-wide survey found it
to be distributed throughout. The in-
tensity of pest infestation on local cul-
tivars, *viz.,* 'Gulab khas', 'Heem sagar' and
'Kancha meetha' fruits varied from 50 to
70%. In some localities 100% fruits
were infested. The intensity of attack was
recorded to be much more in plains than
in hilly regions or places adjoining them.
Flood prone areas were subjected to less
pest infestation, presumably due to heavy
mortality of hibernating adults on the
ground. The pest was also recorded from
Manipur and Mizoram States.

To our knowledge, there are no
published records of the mango nut
weevils, *Sternochetus* spp., developing in
any fruit but mango *(Mangifera indica).*
In the areas surveyed in the present study
the main host of *S. gravis* was mango
but the weevils also attacked and bred
successfully, both in the field and in the
laboratory, in the fruits of a native,
wildly grown species, *M. sylvatica.* It is
an uncommon species in Tripura and
yields small and sour fruits. Out of a
number of hosts tested, forced oviposi-
tion was obtained only in case of potato
but only a few eggs were laid and the
infestation symptoms failed to develop.
The present laboratory observations on
S. gravis did not conform to the obser-
vations of BALOCK & KOZUMA (1964)
who reported that *S. mangiferae* weevils
oviposited freely on Irish potato and
larvae tunneled for short distances into
the flesh. Forced oviposition in the
laboratory on a number of fruits including
peach, *litchi,* plum, string bean and
several varieties of apple reported by
them cannot be corroborated on the basis
of the present study. It may be inferred,
therefore, that the two species of mango

stone weevils possess not only morpho-
logical differences but distinct oviposi-
tional preferences as well.

Adult stage

Emergence and hibernation: In the
culture maintained in the laboratory,
emergence began in early May in 1982
and 1984, and in the third week of May
in 1983. The first adults that emerged
were those which could not succeeed
entering the seeds. Such weevils had
formed in the later season and by that
time seeds had acquired their full hard
coat. Only 10 to 15% of such adults
emerged before the fall of fruits and they
cut their way out of flesh with their mouth
parts and usually followed the exit route
opposite to that followed in their larval
stage, ruining the whole fruit. An exit
hole in the upper side of the fruit was
clearly visible. The rest of them emerged
after the fruits had fallen and decaying
occurred, which usually took four to
eight weeks.

Under field conditions, 58.5% of the
total adults hibernated in seeds. The
rest, on coming out of the fruits, started
searching a suitable shelter and most of
them were found under decaying fruits,
leaf litter and pebbles, in crevices and
refuse materials in the orchards. In no
case they were found hidden under loose
bark on mango trunks and in branch
terminals as reported by BALOCK &
KOZUMA (1964) in *S. mangiferae.*

Weevil emergence data from fruits
collected in early May and held in
laboratory cages showed that out of 161
adults, 75.5% emerged in 3 to 30 days
and the remaining continued up to the last
week of June.

Under laboratory conditions, out of
the various choices offered to emerged

adults for hibernation, 55.5% chose
decaying fruits, 21% leaf litter, 12% farm
yard manure heap and remainder the
top and crevices of the cages. The
hibernation came to an end in the last
week of February in 1983 and in the first
week of March in 1984. The hibernation
phenomenon and places of hibernation
observed are in general agreement with
the observations of VAN DINE (1906),
who found that during non-fruiting periods
weevils hibernated by the hundreds in
crevices of fences and stone walls near
mango trees.

The newly-emerged adults were sex-
ually immature with high body fat con-
tent, and until break of hibernation the
reproductive system showed no develop-
ment. Periodic dissection of adults
showed the reproductive system in all
cases to be undeveloped and very little
feeding was observed, suggesting that
the weevils were hibernating. Climatically,
the hibernation period coincided with
sporadic rainfall, hot and humid (July—
September) and moderately cold weather
(October—February). No mango fruits
were available during this period. It
could not be ascertained whether this
period of retarded reproductive develop-
ment was truly hibernation in respect of
abiotic or biotic factors or whether it
was an obligatory preoviposition develop-
mental period.

Longevity and survival: Adults were
long-lived even under unfavourable con-
ditions. Data showed that only 20 to 30%
of adults emerging in the previous sea-
son survived till the next fruiting season,
the duration of which varied from 240 to
290 days. The survival percetage was
more (30.5 to 50%) when the adults
hibernated in seeds as compared to those
which found shelter elsewhere (5 to 18%).

When the adults, collected from fields in the last week of June were kept in the laboratory cages to study longevity, females usually outlived the males (Table 1). Although in both sexes provision of food and water increased the longevity it did not prove to be significant in the case of males. In females, the maximum longevity was recorded on fruit pulp and water. The next highest longevity was on fruit pulp only. The two treatments did not differ significantly from each other. When no food and water or only water was provided, the longevity of females was significantly reduced.

TABLE 1. Effect of food on the longevity of mango nut weevil adults under laboratory condition.

Treatment	days of survival*	
	male	female
Fruit pulp and water	110.8	135.0
Fruit pulp	103.8	116.2
Water	101.0	79.4
Control (without food and water)	82.5	82.2
Sem ±	10.42	19.99
CD at 5%	NS	34.05
CD at 1%	NS	49.54

*Based on 5 replications containing 10 adults each.

When disturbed, weevils usually dropped to the ground and remained motionless. Stridulation appeared to play a role in the communication; both sexes were observed to stridulate when disturbed by rapidly moving the tip of the abdomen against the elytra. They possess well-developed wings but were found to be very poor fliers and flew only 50 to 90 cm,

and that too only in horizontal direction. Feigning death, hibernation, long-life and poor flying capacity in *S. mangiferae* were recorded earlier by BALOCK & KOZUMA (1964). However, MCBRIDE (1935) reported rich flying in *S. mangiferae*.

The newly-formed adults were rusty brown in colour which became darker gradually with age. Males averaged 6 5 ± 0.65 mm in length and 3.9 ± 0.45 mm in width. Females were slightly bigger (6.6 ± 0.45 mm in length and 4.0 ± 0.53 mm in width) than the males. The difference in size, however, may not be taken as an accurate means of determining sex. Also, no superficial morphological differences in either sex could be found except that the egg bearing females were identifiable by their swollen abdomen. The adults could only be sexed on the basis of their anal plate, which was convex with a sharp end in case of females while in males it was less convex and slightly flattened.

Sex ratio: The females always outnumbered the males. The ratio of males to females was approximately 1:1.4,

Mating: Mating was observed 10 to 15 days after hibernation was over and the adults managed to reach terminal branches of the tree. In laboratory it occurred in the evening hours. The male chased the female and succeeded in mounting over the female in the superimposed position facing the same direction. It held its grip by keeping the legs closely adhered to its body. The female seemed to express its annoyance by moving its abdomen right or left. It continued to wander for one or two hours on the foliage of the plants. The female, looking tired, then stopped under the shady parts of the foliage. Now the male opened the female genitalia by

inserting its last tarsal claws, and slightly slipped backwards, making an angle of 45° with the female body. It easily inserted its penis in the vagina and remained in coitus for 15 to 22 minutes. Mating usually occurred once or twice but sometimes it occurred as many as five times. After mating, male crawled away while the female remained at the same spot for a few minutes. At times, male rode over male. Quite often mating pairs fell off to the ground when disturbed by wind or other agencies.

Oviposition: The egg–laying season of the weevil was found to be restricted from March to May. Eggs were laid singly on the developing mango fruits from the marble size onwards up to half–grown fruits. One fruit usually contained two to three eggs, although as many as seven eggs were observed.

In the laboratory the female was observed wandering all over the fruit searching for a suitable spot for oviposition. It then made a shallow depression by injuring the tissues around the spot and then oviposited an egg. After depositing the egg it emitted a brownish exudate from its abdomen over the egg which covered it completely. The hard brown encrustation seemed to provide protection to eggs from adverse climatic conditions and to newly–hatched grubs

from wandering away. After oviposition the female turned round once more and made, now with the help of its mouth, a crescent shaped cut near the posterior end of the egg. This cut, unlike the shallow depression scooped out earlier, was so deep that there was a copious flow of liquid from it and the liquid also covered the egg completely and dried up into a kind of resinous protective covering for the egg.

Fecundity and Hatching : Oviposition records of four individual females showed that a single female lays as many as 15 eggs one day and a maximum of 115 eggs over a 20 day period. Hatch ranged from 45.1 to 62.5% (Table 2). The duration of egg stage was in general agreement with the observations of SUBRAMANYAN (1925) who recorded 7 days in *S. mangiferae*. The eggs which failed to hatch were either those which were not covered by exudate or were destroyed accidentally. The eggs were elliptical and whitish to light yellowish in colour. An egg, on an average measured 0.6 mm in length and 0.28 mm width. The egg stage occupied 4 to 6.5 days (Table 4).

Larval stage

The newly-hatched larva was very active and began feeding immediately.

TABLE 2. Individual oviposition and egg records of mango nut weevils.

Date of observation	laying period (days)	fecun-dity	per cent hatch	average no. of eggs per day	maximum no. of eggs per day
March 10	15	70	58.5	4.7	14
March 25	20	115	52.2	5.8	11
April 2	18	92	45.1	5.1	12
April 25	16	80	62.5	5.0	15

TABLE 3. Head capsule width of different instars of *S. gravis*.

Instar	number measured	range	mean
I	20	0.233−0.407	0.33 ±0.064
II	25	0.414−0.502	0.465±0.095
III	20	0.521−0.689	0.609±0.048
IV	23	0.741−0.894	0.811±0.069
V	22	0.957−1.13	1.08 ±0.092

After hatching, it entered the fruit by cutting a hole through the chorion of the egg on the side in contact with the fruit. It burrowed through the flesh, and only in the early mango season was able to reach within the seed.

The larva passed through five instars which were determined by measuring the width of the head capsule of 110 individual larvae (Table 3). The average length of different instars, from first to fifth, measured 4.9, 6.0, 9.0, 10.0 and 12.0 mm respectively. The larval duration varied from 27 to 39 days. The percentage of larval mortality varied from 30 to 60. The larval duration recorded in the present study is in general agreement with the observations of SUBRAMANYAN (1925) and BALOCK & KOZUMA (1964) who reported 36 days and 23 days respectively in *S. mangiferae*.

Pupal stage

Pupation occurred inside the fruit. The location of pupation, however, was influenced by the extent of maturity of the fruit. From the last week of April until mid–May pupation occurred within the seed. Thereafter it mostly occurred in mango pulp. One fruit usually contained one pupa; only in 7% cases two pupae were recorded per fruit. The pupal stage was short and varied from 7 to 10 days. When newly formed, pupae

TABLE 4. Effect of three different temperature regimes on the development of mango nut weevil in Agartala.

Stage of development	room temperature								
	22 ± 3°C March—April			24 ± 3°C (April—May)			27 ± 2°C (May—June)		
	min.	max.	mean	min.	max.	mean	min.	max.	mean
			(days)			(days)			(days)
Egg	4.0	6.5	4.7 ± 0.89	4.0	6.0	4.8 ± 0.92	4.0	6.5	5.4 ± 0.93
Larva									
I instar	4.5	6.5	5.3 ± 0.2	4.5	6.0	5.2 ± 0.67	5.0	7.0	5.7 ± 0.71
II instar	4.0	6.0	5.4 ± 0.84	4.0	6.0	5.2 ± 0.92	4.0	6.0	5.1 ± 0.87
III instar	4.5	6.5	5.6 ± 0.27	4.0	6.0	5.2 ± 0.84	6.0	7.0	6.66 ± 0.05
IV instar	6.0	7.0	6.4 ± 0.46	5.0	6.5	5.6 ± 0.66	8.0	10.0	9.48 ± 0.69
V instar	8.0	10.0	9.2 ± 0.79	5.0	7.0	5.8 ± 0.76	7.0	9.0	8.2 ± 0.67
Pupa	7.0	8.5	7.6 ± 0.48	8.0	10.0	8.8 ± 0.67	7.0	9.0	7.95 ± 0.16
Total	38.0	51.0		34.5	47.5		41.0	54.5	

were almost pure white. At the end of pupation period the colour changed to a light brown. Pupa measured, on an average, 9 mm in length. No mortality was observed at the pupal stage.

There has been a lot of controversy with regard to the place of pupation of mango nut weevils. A number of authors, *viz.*, VAN DINE (1906), RUTHERFORD (1914), BAINBRIDGE & FLETCHER (1917), LEEFMANS (1927), SUBRAMANYAN (1925) and JARVIS (1946) have reported pupation of *S. mangiferae* within seed; BALOCK & KOZUMA (1964) reported it in pulp and LEFROY & HOWLET (1909) and DAMMERMAN (1929) in soil. In *S. gravis* it was reported to occur in pulp (SEN, 1923) and in soil (LEFROY & HOWLETT, 1909; LEEFMANS, 1927). The present investigation partially supports the observations of SEN (1923) and contradicts LEFORY & HOWLETT (1909) and LEEFMANS (1927) as not even in a single case pupation was observed in soil under field conditions. The duration of the pupal stage was found to be in general agreement with the observations of SUBRAMYNYAN (1925) and BALOCK & KOZUMA (1964) who reported 7 days in *S. mangiferae.*

Effect of various temperatures on life-cycle

The life-cycle studied at three temperatures revealed (Table 4) that under laboratory conditions the most conducive temperature for development was $24 \pm 3°C$ at which the larval growth was fastest (34.5 to 47.5 days), as compared to 38 to 51 days at $22 \pm 3°C$ and 41 to 54.5 days at $27 \pm 2°C$. The pupal period varied from 7 to 10 days under different temperature regimes and was not influenced by the various temperatures. The egg stage was also not influenced by various temperatures under study.

Seasonal history and number of generations

Hibernating adult population became active from the last week of February to the last week of March. Eggs were found on the fruits during mid–March to last week of April, the larvae during last week of March to end of June, and the pupae during early May to June, inside the fruit. The emergence of adults from early May to June was immediately followed by a period of long inactivation; they hibernated inside seeds or other shelters until the last week of February. The activity of adults synchronised with the appearance of mango flowers and fruit setting.

The insect passed through only one generation in a year. The duration of one complete life–cycle, from laying of the egg to the emergence of adult, varied from 34 to 55 days. The observations recorded here are in general agreement with the findings of SEN (1923) who reported completion of the life–cycle in 45 days and one generation in a year of *S. gravis*. Similar observations were recorded by SUBRAMANYAN (1925), KEISER (1959), DAVID & SUNDARABABU (1962) and BALOCK & KOZUMA (1964) who worked on *S. mangiferae.*

Natural enemies

Two species of ants, *viz.*, *Oecophylla smaragdina* and *Camponotus* sp. abundant on the mango trees were found to be disturbing the adult weevils. As a result, mating and egg laying were affected. Under laboratory conditions another species of ant, *Monomorium* sp. was found to devour adults by cutting them into pieces. They also killed exposed grubs. Hibernating adults, both in field and laboratory, were frequently infected by *Aspergillus* sp. The larvae, pupae and hibernating adults were also frequently

parasitised by *Rhizoglyphus* sp. (Acarina). However, the role exercised by natural enemies seemed very limited.

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RESPONSE OF THE PARASITOID, *EUCELATORIA BRYANI* SABROSKY (DIPTERA : TACHINIDAE) TO DIFFERENT PESTICIDES

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A total of thirteen pesticides were evaluated at recommended field dose for contact toxicity to the tachinid, *Eucelatoria bryani* Sabrosky. Based on the mortality of the parasitoid at the end of a five day test period, the ranking of the pesticides in the order of toxicity was as follows dicofol = Dithane = sulphur < phosalone < monocrotophos < carbaryl < endosulfan = quinalphos = fenitrothion = methyl demeton = chlorpyriphos = dimethoate = malathion.

(Key words: Eucelatoria bryani, pesticide)

Majority of modern synthetic pesticides have a detrimental effect on beneficial insects including natural enemies of crop pests, but the degree varies from one compound to another. In order to develop a sound integrated pest control programme, it is necessary to have some knowledge on the safety of different pesticides to the natural enemy complex occurring in a given crop. Screening of different pesticides for their selectivity to some entomophages has been carried out earlier by several workers (BARTLETT, 1963; STERN, 1963; PLAPP & BULL, 1978; WILKINSON *et al.*, 1975). Little or no information is available as yet on the effect of pesticides on the tachinid, *Eucelatoria bryani* Sabrosky, a common larval parasite of *Heliothis* spp. in several parts of U. S. A. (JACKSON *et al.*, 1969). This parasite was introduced

into India for trials against *Heliothis armigera* (Hubner) (SANKARAN & NAGARAJA, 1979) and releases of *E. bryani* were made in India in crops like tomato, field beans, etc. and also recovered (PAWAR *et al.*, 1981). The present study was conducted to determine the relative contact toxicity of several pesticides to adults of *E. bryani*.

E. bryani was reared on *H. armigera* in the laboratory as described by SANKARAN and NAGARAJA (1979), and *H. armigera* on the artificial diet developed by NAGARKATTI and SATYA PRAKASH (1974). Since adult parasites are generally considered highly susceptible to insecticides, in the present study one to two day old adults of *E. bryani* were used as test insects.

Toxicity of endosulfan (0.07%), (Thiodan 35 EC), Carbaryl (0.10%) (Bangvin 50 WP), quinalphos (0.05%) (Ekalux 25 EC), monocrotophos (0.05%)

(Nuvacron 40 EC), phosalone (0.05%) (Zolone 35 EC), fenitrothion (0.05%) (Folithion 50 EC), methyl demeton (0.05%) (Metasystox 50 EC), Chlorpyriphos (0.05%) (Duraban 20 EC), dimethoate (0.05%) (Rogor 30 EC), malathion (0.10%) (Cythion 50 EC), dicofol (0.05%) (Kelthane 18.5 EC), Dithane Z–78 (2 g/l) and sulphur (2 g/l) (Sulfovit 80 WP) to *E. bryani* was tested as suggested by WILKINSON *et al.* (1975). A filter paper strip (15 × 3 cm) was soaked in the pesticide solution, dried in sunlight for about 15 minutes was kept in a glass vial (20 × 4 cm). Ten adult flies were released into a single vial and provided with a cotton swab soaked in 50% honey solution. The mouth of the vial was covered with a piece of thin muslin (cheese) cloth to provide adequate aeration. An untreated check, with filter paper soaked in water, was also maintained to correct the mortality in the pesticidal treatment. Each pesticidal treatment was replicated thrice with 5 males and 5 females of *E. bryani* per replicate. The parasites were exposed continuously for a period of five days and mortality was recorded at 1, 2, 4, 16, 24, 48, 72, 96 and 120 hours.

Zero values in the mortality of the parasitoid were converted into 0.01 and the data were transformed into corresponding angles (Arc-sine percentage) for statistical analysis. 'F' test was used to analyse the differences in the mortality of the parasite due to different pesticidal treatments.

Response of *E. bryani* to different pesticides varied significantly (Table 1). Fungicides like Dithane Z–78, wettable sulphur and the acaricide dicofol were totally non-toxic to the adult tachinid. Among the insecticides tested, phosalone

and monocrotophos were less toxic. There was no mortality during the continuous exposure for 48 hours to these chemicals. Mortality in phosalone treated flies was 3.3 per cent after 72 hours and upto 120 hours. With monocrotophos, 3.3 per cent mortality after 72 hours rose to 6.7 per cent after 96 hours but did not show further change even upto 120 hours.

With carbaryl, 23.3 per cent mortality occurred after one hour, 50 per cent mortal ty after two hours and 53.3 per cent mortality after four hours with no subsequent change even upto 120 hours. Among the remaining chemicals, fenitrothion, methyl demeton and chlorophyriphos caused 100% mortality within two hours of exposure. Quinalphos inflicted 100% mortality within four hours of exposure and endosulfan, dimethoate and malathion caused 100% mortality of the tachinid within 16 hours of exposure.

Based on the mortality of the parasite at the end of a five day test period, the ranking of the pesticides in the order of toxicity was as follows: Difofol ⇌ Dithane Z–78 = sulphur < phosalone monocrotophos < carbaryl < endosulfan = quinalphos ⇌ fenitrothin ⇌ methyl demeton ⇌ chlorpyriphos = dimethoate = malathion.

Phosalone and monocrotophos are relatively less toxic to *E. bryani* among the insecticides tested. The non-toxic or less toxic nature of phosalone to some natural enemies was reported earlier by LELIEVRE (1980). The toxicity of carbaryl to *E. bryani* is similar to that reported by WILKINSON *et al.* (1975) to another tachinid. The above three chemicals are also effective against many insect pests and commonly used in cotton, tomato, chick pea etc. (SELLAMMAL & PARAMESWARAN, 1979; MATHUR *et al.*, 1974; AGRAWAL *et al.*, 1977).

TABLE 1. Effect of pesticidal treatments on the adults of *E. bryani,*

Pesticide		Mortality (%) during exposure in hours								
		1	2	5	16	24	48	72	96	120
1	endosulfan	0.0 (0.6)	0.0 (0.6)	3.3 (6.7)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
2	carbaryl	0.0 (0.6)	0.0 (0.6)	23.3 (29.2)	50.0 (45.9)	53.3 (47.4)	53.3 (47.4)	53.3 (47.4)	53.3 (47.4)	53.3 (47.4)
3	quinalphos	0.0 (0.6)	0.0 (0.6)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
4	monocrotophos	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	3.3 (6.7)	6.7 (9.4)	6.7 (9.4)
5	phosalone	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	3.3 (6.7)	3.3 (6.7)	3.3 (6.7)
6	fenitrothion	0.0 (0.6)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
7	methyl demeton	0.0 (0.6)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
8	chlorpyriphos	83.3 (71.3)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
9	dimethoate	30.0 (33.8)	43.3 (41.9)	83.0 (71.3)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
10	malathion	16.7 (20.4)	50.0 (45.5)	93.3 (97.2)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
11	dicofol	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)
12	dithane Z-78	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)
13	sulphur	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)

Figures in parentheses are sine inversion values.

Comparison of significant effects.

		Level of significance	Critical difference (P = 0.05)
1	Between pesticidal treatments	0.01	1.85
2	Between periods	0.01	2.22
3	Interaction between pesticides and periods	0.01	6.67

Spray applications of Dithane Z—78, wettable sulphur and dicofol have been generally recommended for the control of disease and mites in many crops, especially cotton. The present finding of non-toxic nature of the above three chemicals to *E. bryani* is in agreement with the reports of STEINER (1938) and BARTLETT (1963) and Kelthane (dicofol) and Zineb (Dithane Z—78) were non-toxic to parasites like *Aphytis lingnanensis* Compere and *Spalangia drosophilae* Ashmead (Bartlett, 1963) and wettable sulphur had no influence on *Aphelopus typhlocybae* Muesebeck (Steiner, 1938).

All the remaining insecticides were detrimental to *E. bryani*. The toxicity of dimethoate, malathion and endosulfan to fiive hymenopteran parasites was reported earlier by BARTLETT (1963).

Based on the above results, *E. bryani* can be released in field crops like cotton, tomato, chick pea etc., even when phosalone, monocrotophos, Dithane Z-78, sulphur and dicofol have been sprayed. Since *E. bryani* has shown promise of establishment in India in crops like cotton, tomato and *Dolichos lab-lab*, phosalone and monocrotophos should be used with caution.

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TWO NEW SPECIES OF WHITEFLIES (ALEYRODIDAE : HOMOPTERA) FROM INDIA AND SRI LANKA

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During a broad survey undertaken in South India and Sri Lanka, two new species *viz.*, *Aleuroclava orientalis* and *Aleurolobus orientalis* were found infesting respectively *Holoptelea integrifolia* and *Securinega virosa* in both the countries. They are illustrated and described in this paper.

(Key words: Aleuroclava orientalls, Aleurolobus orientalis, Holoptelea integrifolia, Securinega virosa)

During the course of collection of whiteflies from various plants for taxonomic studies in the years 1984–1986 both in South India and Sri Lanka, two species of whiteflies were collected from *Holoptelea integrifolia* and *Securinega virosa* in both the countries. A study of the specimens revealed them to be new to science. While the Genus *Aleuroclava* is represented in India, this is the first time *Aleuroclava* is reported from Sri Lanka though 38 species of aleyrodids have been reported from Sri Lanka (Mound & Halsey, 1978). A number of species of *Aleurolobus* eccur in both the countries but the one that has been observed on *Securinega virosa* is new to science. In this paper the two species have been described.

1. Aleuroclava orientalis sp. nov.

(Figures 1—3)

Pupal case: White, flat, thin, on undersurface of leaves. Elliptical, broadest in the first abdominal segment area and deflexed in the prothoracic and abdominal regions; 0.580—0.730 mm long and 0.400—0.540 mm wide.

Margin: Regularly crenulate, about 26—28 crenulations in 0.1 mm; emarginate at thoracic and caudal pore regions; anterior and posterior marginal setae about 10^{μ} long.

Dorsal surface: Submargin with 43 pairs of papillae; subdorsum with faint granulations; base of cephalic setae with granules. Longitudinal moulting suture reaching submargin while transverse moulting suture reaches subdorsum. Paired cephalic setae $162.5-175 \mu$m, first abdominal setae 230μm, eighth abdominal setae 10μm and caudal setae 90μm long. Median tubercles evident on abdominal segments 1, 2 and 3.

Pro-mesothoracic, meso–metathoracic and abdominal segment sutures distinct. First abdominal segment longest 35μm, third and seventh abdominal segments 25μm, abdominal segments two, four and five of equal length 22.5μm, and sixth abdominal segment smallest 20μm long. Eighth abdominal segment 32.5μm, seventh abdominal segment shorter than eighth but longer than sixth.
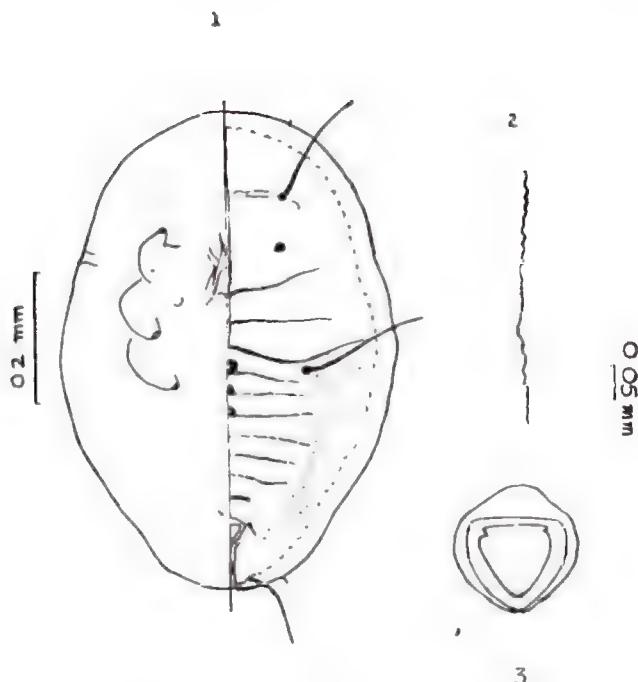
Figs. 1—3 1. Pupal case of *Aleuroclava ortentalis* sp. nov. 2. Margin; 3. Vasiform orifice.

Vasiform orifice cordate shaped, as long as wide, 37.5μm. Operculum similarly shaped, 22.5μm concealing lingula. Caudal furrow 40μm long, wide at base of vasiform orifice and slightly constricted near pore end.

*Ventral surface:* Spiracles, legs and mouth parts discernible. Thoracic and caudal tracheal folds not discernible. Ventral abdominal setae 5μm long and 25μm apart. Adhesive sacs evident.

Host : Holoptelea integrifolia

Material examined : **Holotype :** One pupal case on slide, INDIA: TAMILNADU : COIMBATORE : *Holoptelea integrifolia*, 19. vi. 1985, R. W. Alexander Jesudasan. **Paratype :** nineteen paratypes on slides bearing the same details; nine slides bearing the details SRILANKA : KANDY : *Holoptelea Integrifolia*, 1. vii. 1986, B. V. David. Pupal cases in the collections of the authors. Paratypes being deposited in the collections of the Systematic Entomology Laboratory, USDA, Maryland; the British Museum (Natural History), London; the Division of Entomology, Indian Agricultural Research Institute, New Delhi; Zoological Survey of India, Calcutta.

This species is allied to *Aleurotuberculatus malloti* Takahashi (Takahalhi, 1932) in the shape of pupal case; presence of submarginal papillae, cephalic setae, shape of vasiform orifice but differs from it in the absence of elongate first abdominal setae.
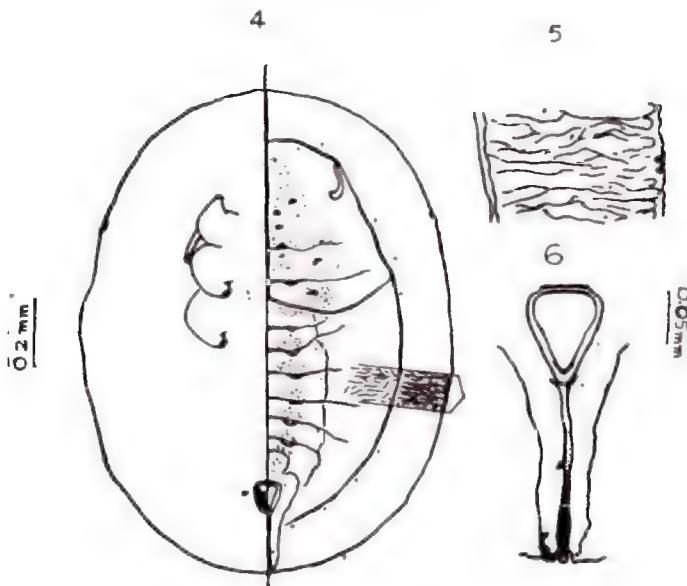
Figs. 4—6 4. Pupal case of *Aleurolobus orientalis* sp. nov., 5. Margin and submargin; 6. Vasiform orifice.

2. Aleurolobus orientalis sp. nov.
(Fig. 4—6)

Pupal case: Black, oval, on the surface of leaves, no wax; ♀ 1.224—1.408 mm long and 0.979—1.117 mm wide: ♂ 1.129—1.132 long and 0.764—0.796 mm wide, with a dark brown patch in the median region dorsum.

Margin: Regularly dentate; 7 teeth in 0.1 mm, differentiated in the thoracic tracheal pore region by a distinct tooth and in the caudal tracheal pore region by a tooth; paired posterior marginal setae 25μm long.

Dorsal surface: Submargin demarcated by a very distinct suture, $160—170\mu$m wide, with 10 pairs of minute setae, 4 in the cephalothorax and 6 in the abdomen. Submarginal lines reaching the suture. Caudal setae minute. Subdorsum with waxy markings and granulations.

Cephalic, first abdominal and eighth abdominal setae of equal length, 5μm; longitudinal moulting suture reaching margin while transverse moulting suture reaching submarginal suture.

Abdominal segment sixth 48—65μm, seventh 25—35μm and eighth 90—105μm long. Seventh abdominal segment approximately half the length of sixth and two thirds the length of eighth abdominal segment.

Vasiform orifice triangular shaped, 85—92.5μm long and 75—80μm wide; operculum similarly shaped 77.5—85μm long and 63.8—66.3μm wide, concealing the lingula.

Ventral surface: Tracheal folds and ventral abdominal setae not discernible. Antenna reaching beyond prothoracic leg, mouth parts and spiracles not evident. Floor of operculum possesses honey comb like structure.

Host: *Securinega virosa* (= *Fluggea virosa*)

Material examined

Holotype: One pupal case on slide, INDIA: TAMIL NADU: CHINGLEPUT DISTRICT Padappai, *Securinega varisa*, 1. vi. 1984, R. W. Alexander Jesudasan. **Paratypes:** Seven paratypes (5♀♀ + 2♂♂) on slides bearing the same details; six slides, (4♀♀ + 2♂♂) SRILANKA : SIGIRIYA, *Securinega virosa*, 2. vii. 1976, B. V. David. Pupal cases on leaves in the collections of the authors.

This species is close to *Aleurolobus onitshae* Mound (Mound, 1965) in shape of pupal case, possession of ten pairs of minute submarginal setae and also in their positions but differs from it in the presence of thoracic tracheal comb having 3 teeth, lateral depressions, eye spots and markings in the subdorsum. This species is also allied to *Aleurolobus niloticus* Priesner & Hosny (Prieszer & Hosny, 1934) in the presence of teeth in thoracic tracheal pore region, articulation of moulting sutures but differs from it in the shape and size of vasiform orifice and operculum.

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A NEW WHITEFLY *BEMISIA GRAMINIS* SP. NOV. (ALEYRODIDAE : HOMOPTERA) FROM INDIA

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A new species of Whitefly, *Bemisia graminis*, infesting leaves of *Apluda mutica*, *Echinochloa colonum*, *Echinochloa crusgalli* and *Oryza sativa* (Poaceae) is described and illustrated.

(Key words: Bemisia graminis, Apluda mutica, Echinochloa colonum, Echinochloa crusgalli, Oryza sativa)

During the course of field study of whiteflies, a species of *Bemisia* was collected during October 1985 from *Echinochloa colonum* and *Echinochloa crusgalli* at Pondicherry, South India. The same species was again collected during July 1986 from *Apluda mutica* at the Fredrick Institute of Plant Protection and Toxicology, Padappai, South India. A careful study of the morphological features of the pupal cases showed it to be a distinct species, new to science and hence it is described in this paper, under the name *Bemisia graminis*. Further, a detailed study of the specimens collected from *Oryza sativa* earlier in 1970 by the first author and included under the name *Bemisia tabaci* (Gennadius) (David & Subramaniam (1976) has shown them to be identical with the new species described here.

Bemisia graminis sp. nov. (Figures 1—4)

Pupal: White, elliptically elongate 0.95—0.97 mm long and 0.53—0.58 mm wide, found on the under surface of leaves.

Margin: Irregularly crenulate, paired anterior and posterior marginal setae 10 μ long. Thoracic tracheal combs and teeth absent, caudal tracheal pore end slightly indented; caudal setae arising on tubercles, 90—92 μm long.

Dorsal surface: A pair of cephalic setae arising on tubercles 15 μ long; first abdominal setae 12μm long, and eighth abdominal setae 10 μm long. Subdorsum with seven pairs of setae, two on cephalothorax and five on abdominal region. Pupal case collected from *Echinochloa colonum* leaves, which are non–glabrous showed the two cephalothoracic setae on subdorsum and the anterior seta of the five abdominal setae on subdorsum to be elongate, measuring respectively 120μm, 115μm and 110μm 10 long. The submedian depressions constitute one on prothoracic segment, three on mesothoracic segment, two on metathoracic segment and one each on 1—6 abdominal segments. Transverse moulting suture runs posteriorly and bends to the anterior reaching the submargin. Longitudinal moulting suture almost reaching submargin.
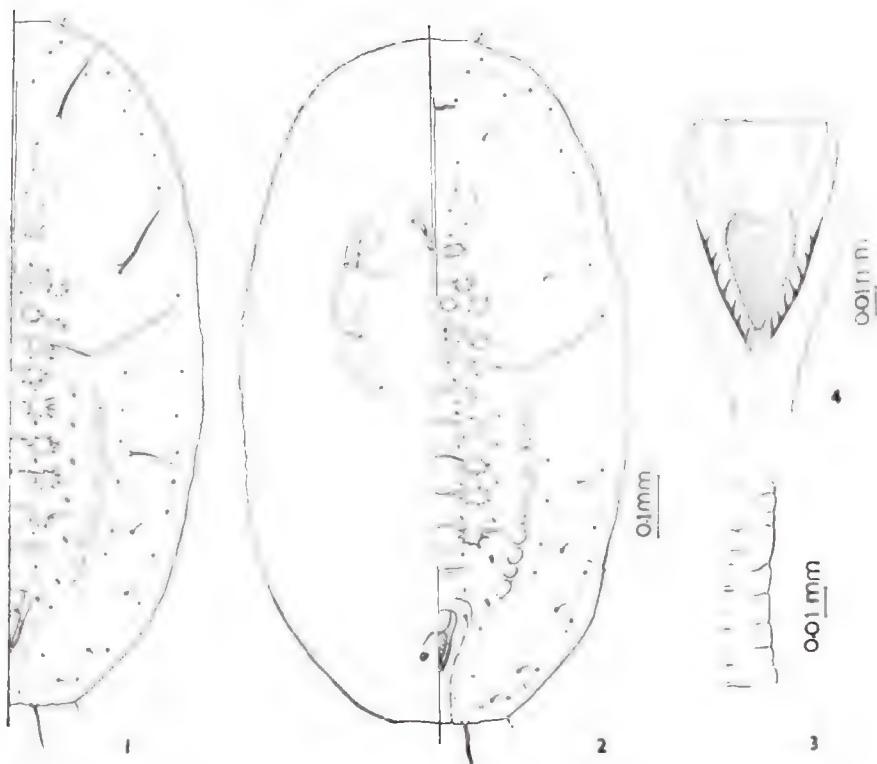
Bemisia graminis sp. nov.,   1. Pupal case on *Echinochloa colonum* leaf;
2. Pupal case on *Apluda mutica* leaf; 3. Margin; 4. Vasiform orifice.

Thoracic tracheal furrows not discernible, caudal tracheal furrow little shorter than the vasiform orifice, 75 μm long, 25 μm wide at base and 21 μm wide at caudal end. A row of sparsely distributed pores on submargin and subdorsum and scattered in cephalic region present; pores and porretts in two rows are present on dorsum. Eighth abdominal segment short.

Vasiform orifice : Triangular shaped, 90μm long and 25μm wide with 5–7 pairs of lateral teeth. Operculum subcordate, lingula setose, exposed, bears a pair of 23μm long setae sub-apically. Ridges slightly evident on both sides of vasiform orifice.

Ventral Surface : Ventral obdominal setae 22μm long and 27μm apart. Thoracic spiracles and abdominal spiracles evident. Antennae not reaching beyond fore legs. Thoracic and tracheal folds not dissernible.

Material examined : **Holotype** : One pupal case on slide. INDIA: TAMIL NADU: PADAPPAI: *Apluda mutica*, 21. vii 1986. Aagustine. **Paratypes :** Ten paratypes on slides bearing the same details; Four slides bearing details, INDIA: PONDICHE-RRY *Ehinochloa colonum*, 19. ix. 1985, Augustine. Five slides bearing the details INDIA : PONDICHERRY : *Ehinochloa crusgalli*, 19. ix. 1985, Augustine and three slides bearing the details, INDIA : KAYARAMAEDU:

Oryza sativa, 21. viii. 1970. B. V. David. Pupal cases are in the collections of the authors. Paratypes being deposited in the collections of the Systematic Entomology Laboratory, USDA, Maryland; the British Nuseum (Natural History) London; the Division of Entomology, Indian Agricultural Research Institute, New Delhi; the Zoological Survey of India, Calcutta.

This species is close to *Bemisia formosana* Takahashi (Takahasi, 1933) in the shape and length of pupal case, presence of submedian depression on the abdominal segments but distinct from it possessing the cephalic setae, two setae on subdorsum of the cephalothorax and five on the subdorsum of abdomen, presence of submedian depressions on thoracic segments, presence of 5—7 lateral teeth at the sides of the vasiform orifice, and setose lingula.

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HISTOPATHOLOGICAL EFFECTS OF HEXACHLOROCYCLO-HEXANE (HCH) ON THE TESTES OF ADULT *POECILOCERUS PICTUS* (FABR.) ORTHOPTERA : ACRIDIDAE

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The mature male grasshoppers were injected on alternate days with 0.01% HCH for different time intervals. Histopathological studies reveal not much of change after 4 days, but as the treatment is continued the damage is further increased. Loosening of the germ cells, pycnosis of the spermatogonia, spermatocytes, hypertrophied spermatids, hypertrophied and dissociated spermatozoa, the formation of 'brown coloured body' between the testes follicle and their subsequent melanization were the marked changes observed. It can be concluded that HCH makes the tissue hyperactive and probably there is stress which brings about cellular deformations.

(Key words: grasshopper, HCH, testis, *Poecilocerus pictus)*

INTRODUCTION

Organochlorine insecticides have a broad spectrum of insecticide efficacy and their biological activity extends to non-target organisms, besides the target organisms. A good amount of information on the toxicities of pesticides on aquatic insects is available (BRIDGES & ANDREWS, 1961; DIMOND, 1067; IDE, 1967). Histopathological investigations to determine the effect of insecticides on terrestrial insects have received comparatively little attention. The carcinogenic action of certain organochlorines has been examined in mammals (FARBER, 1980). As far as the author is aware the effect of HCH on the testes of insects has not been described. Thus the present study was undertaken with a view to see if HCH has any tumorigenic effect on the testes of *P. pictus,* especially when NAGASAKI *et al.* (1971) reported the development of hepatomas in mice treated with HCH.

MATERIAL AND METHODS

The nymphs of *P. pictus* were collected from the fields around Saugor and kept in glass fronted cages. Newly moulted males were kept in separate bottles and marked for their ages. Ten days old males were used for the experiment.

Technical grade of HCH (90%), which was supplied by M/s Union Carbide, Bhopal, was used for the experiment. The insecticide was dissolved in acetone at a concentration of 0.1% and diluted further with distilled water prior to the experiment. The males were injected on alternate days with 0.2 ml of 0.01% HCH. Comparable 0.1% acetone injected and untreated individuals constituted the controls. The males were vivisected after 4, 6, 8, 10, 12, 14 and 16 days of treatment. The testis was taken out, washed in physiological saline, fixed in aqueous Bouin's fluid, dehydrated in graded alcohols, cleared in xylene and embedded in paraffin wax (60—62°C). Sections cut at 6μm were stained with haematoxylin–eosin. The results are based on observations taken in three replicates of 15 insects each.

RESULTS

Histology of normal testis:

The testicular follicle is bounded on the outside by a compact fibrous connective tisssue layer forming the basement membrane which supports the germinal tissues (Fig. 1). Each follicle is divided by a thin membrane into apical germarium and series of cysts containing developing germ cells. The posterior part of the follicle has maturing sperms. The developing spermatozoa group together into cysts.

Control series:

The control series of the present investigation showed no deviation from the normal histology, but a lot of degenerative changes appear between 4 to 16 days in treated insects.

Histopathology of the testes :

4to 8 days

By 4 days, there seems no to have evident effect on the germ cells except that the late spermatids and the spermatozoa appear as clumped (Fig. 2) and a gaint sperm bundle is seen. By 6 days, the primary spermatogonia show abnormally thickened ring shaped chromosomes (Fig. 3a), whereas the chromosomes of the secondary spermatogonia are deeply stained and there seems clumping among them. The spermatocytes are vacuolated, the spermatids are with pycnotic nuclei and the spermatozoa show loose arrangements (Fig. 3b). In 8 days, loosening of the germ cells is evident, the spermatogonia and the spermatocytes show pycnotic nuclei (Fig. 4a). The spermatozoa are scattered to the extent that individual entity of the bundle becomes inconspicuous (Fig 4b).

10 to 12 days :

By 10 days loss of cohesion among the germ cells is more pronounced

and the follicles are vacuolated. The spermatogonia are smaller in size with pycnotic nuclei and reduced cytoplasmic contents (Fig. 5a), the spermatocytes are also with reduced cytoplasmic contents. The spermatozoa are hypertrophied and scattered in the lumen (Fig. 5b). In 12 days, the spermatogonia do not mature, most of the spermatocytes degenerate and hypertrophied spermatids can be seen in the lumen (Fig. 6a). The sperms have lost their tails, between the interfollicular spaces and at few other places 'brown coloured bodies' (probably melanin) can be seen (Fig. 6b).

14 to 16 days :

By 14 days, melanization of the margins of the follicles is further increased (Fig. 7) and the spermatocytes show excessive fragmentation of their chromatin thus leading to their disintegration. Hypertrophied spermatids can be seen displaced from their position and hypertrophied spermatozoa are also dissociated (Fig. 7c). In 16 days general size of the testes is smaller and excessive damage is caused as a result of severe melanization of the follicles. Whatever germ cells are present they have lost their identity and are disintegrated (Fig. 8).

DISCUSSION

So far studies relating to the histopathological effects induced by chlorinated hydrocarbons on the testis of insects have not been made. In the present study *P. pictus*, tissue hyperactivity and cellular deformations were noticed. Although such studies have not been described so far, these observations can be compared with the observations of tissue stress as shown by the effect of apholate on the reproductive organs of *Locusta* by VISWANATH *et al.* (1978).
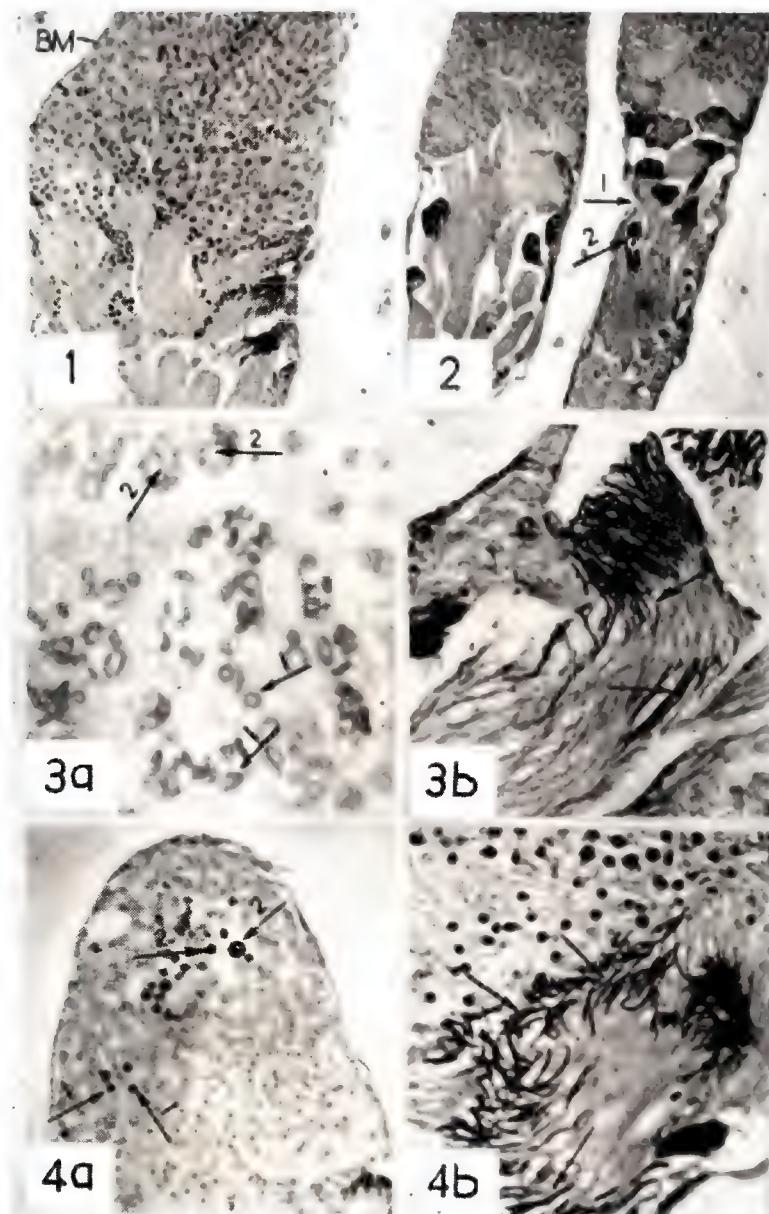
Photomicrographs of L. S. of testes of adult *P. pictus* stained with haematoxylin–eosin.
Fig. 1. Normal testis showing compact arrangement of the germ cells which are supported
on the outside by basement membrane × 80; Fig. 2. Showing distorted shape of the follicles
(arrow 1) and clumped sperm heads (arrow 2) after 4 days treatment × 40; Fig. 3a. Show-
ing abnormally thickened ring shaped chromosomes of the primary spermatogonia (arrow 1),
the primary spermatocytes are vacuolated (arrow 2) after 6 days treatment with HCH × 360;
Fig. 3b. The same showing loose arrangement of sperm bundle (arrows), × 320; Fig. 4a.
Showing pycnotic nuclei of spermatogonia (arrow 1) and pycnotic primary spermatocytes
(arrow 2) after 8 days treatment, × 80; Fig. 4b. The same showing scattered spermatozoa
(arrows), × 200.
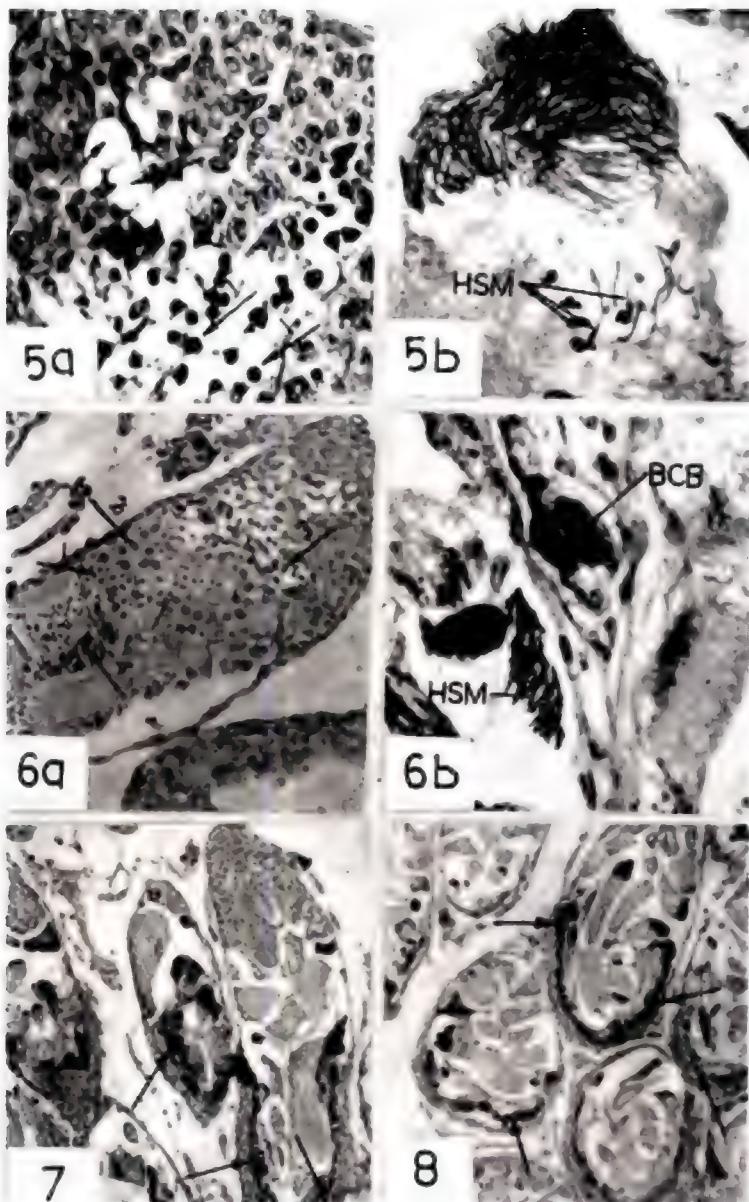
Fig. 5a. showing vacuolization in the testis follicles (arrows)' and pycnotic nuclei and loose arrangement of secondary spermatocytes (arrow 1) after 10 days treatment. × 180; Fig. 5b. The same showing hypertrophied scattered spermatozoa, × 360; Fig. 6a. Showing loose arrangement of germ cells, pycnotic spermatogonia (arrow 1), degenerated chromatin threads of primary spermatocytes (arrow 2), pycnotic nuclei of secondary spermatocytes (arrow 3), and hypertrophied spermatids (arrow 4) after 12 days treatment, × 80; Fig. 6b. The same showing 'brown coloured body' between the interfollicular spaces and sperm heads which are without tails (arrows), × 175; Fig. 7. Showing 'brown coloured body' which is occupying a greater space after 14 days treatment (arrows), × 40; Fig. 8. Showing melanized margins of the follicles (arrows) and remanants of degenerated germ cells, after 16 days treatment, × 40.

Abbreviations : BM—Basement membrane; HSM—Hypertrophied spermatozoa; BCB—Brown coloured body.

The visible damage to the male gonads due to the effect of HCH, appears to be nuclear pycnosis, followed by pycnosis of the cytoplasm and finally degeneration of the germ cells, differentiating germ cells; loss of sperm motility (hypertrophied sperms) and also degeneration and resorption of the spermatozoa. Loss of cohesion among the germ cells was evident after 8 days which became more pronounced as the post treatment was increased, which probably breaks the contact and transport of material from one cell to another, thus affecting normal testicular physiology. Hypertrophied spermatozoa were observed after 10 days, which possessed a flagellum and acrosome each but failed to form bundles through agglutination. However, from 12 to 16 days the sperms had lost their tails and were seen scattered. The hypertrophied sperms reflected disturbed physiological state of activity. In conformity with the present observations VISHWANATH et al. (1978) also observed hypertrophied spermatozoa after 15 days of treatment.

Apart from cellular deformations, the margins of the follicles were melanized. After 12 days a small area between the testes follicle was occupied by 'brown coloured body' probably melanin. Till the 16th day of treatment this brown pigment turned black. In the adipose tissue of HCH treated insects, this brown pigment occurs primarily in the necrotic blood cells and in necrotic tissue encapsulated by blood cells (unpublished observations). However, in the margin of the follicles a few blood cells were seen in the vicinity of the pigment. No mitotic figure was observed in the germ cells, but in HCH treated ovaries, the oocytes divided amitotically and multinucleated oocytes were observed

It can be concluded that HCH makes the tissue hyperactive and there is a stress which brings about cellular deformations. However, HCH has no tumorigenic effect on the testes of *P. pictus* in contrast to mice, where NAGASAKI et al. (1971) reported the development of hepatomas in mice by treating them with HCH. In the present study there isprogressive testicular degradation, resorption and melanization.

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BRIEF COMMUNICATION

EFFECT OF COATING GRANULES OF CARBOFURAN ON THE PERSISTENCE OF ITS TOXICITY TO PEA APHID

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Coating of carbofuran granules with lac, lignin and polyethylene improved the persistence of the toxicity of the insecticide. The coated granules persisted upto 25 days whereas non coated and encapsulated carbofuran (proprietory) persisted only upto 19 days after insecticide application.

(Key words: coated carbofuran granule, persistence of toxicity, *Aphis craccivora)*

Carbofuran is widely used for pest control in granular formulation. Recently coating or encapsulation of the granules with inert and non toxic substances have been introduced to increase the persistence of the insecticide and decrease handling hazards. Persistent toxicity of the insecticide granules coated with lac, lignin and polyethylene to the pea aphid, *Aphis craccivora* Koch was compared to that of a proprietory encapsulated granule and non encapsulated granule (supplied by the Indian Lac Research Institute, Ranchi and RRL, Hyderabad).

The granules were applied to 15 days old cowpea plants raised in pots. Each granular formulation (See Table 1) was applied in quantities calculated to give three doses of the insecticide. Pea aphids were released on the plants enclosed within cages at different intervals after the application of the granules. Mortality counts of the aphids were recorded 24 hours after their release.

Results (Table 1) show that at all the doses tested the persistent toxicity of the insecticide was less in the encapsulated and non encapsulated granules, than that of the coated granules. At 1 and 1.5 kg ai/ha the three formulations of lac coated granules performed almost alike while at the dose of 0.5 kg ai/ha 2.439% granules showed lower persistent toxicity than the lignin and polyethylene coated carbofuran. Toxicity of the coated granules persisted upto 25 days whereas that of encapsulated and non encapsulated carbofuran persisted only upto 19 days after application of the insecticide.

The P T indices (Pradhan, 1967) were higher in lac coated, lignin coated and polyethylene coated carbofuran than in the non encapsulated and encapsulated carbofuran (Table 1). Thus in general, coating of granules with different materials improved the persistence of the insecticide. The studies conducted by Salam *et al.* (1986) showed that the polyethylene based preparation of carbofuran persisted for a longer period than lignin coated and the proprietory encapsulted carbofuran.

TABLE 1. Mean percentage mortality of *A. craccivora* released on cowpea plants treated with carbofuran granules with different types of coatings.

Type of coating	insecticide concentration in granule	insecticide dose kg ai/ha	days after treatment							P	T	PT
			1	3	6	9	15	19	25			
Lac coated	2.702%	1.5	86.66	100.00	100.00	100.00	86.66	53.33	13.33	25	77.14	1928.50
		1.0	93.33	100.00	96.66	100.00	83.33	36.66	23.33	25	76.18	1904.50
		0.5	93.33	100.00	86.66	80.00	86.66	46.66	6.66	25	71.42	1785.25
Lac coated	2.631%	1.5	93.33	100.00	90.00	100.00	100.00	36.66	16.66	25	76.66	1916.50
		1.0	90.00	100.00	100.00	96.66	93.33	30.00	13.33	25	74.76	1869.00
		0.5	83.33	100.00	96.66	73.33	80.00	83.33	10.00	25	68.09	1702.25
Lac coated	2.439%	1.5	96.66	100.00	96.66	86.66	76.66	56.66	23.33	25	76.66	1916.50
		1.0	86.66	93.33	93.33	86.66	83.35	53.33	16.66	25	73.33	1833.00
		0.5	70.00	93.33	80.00	66.66	70.00	26.66	10.00	25	59.52	1488.00
Lignin coated	20%	1.5	96.66	100.00	93.33	86.66	73.33	56.66	26.66	25	76.18	1904.50
		1.0	86.66	100.00	86.66	83.33	70.00	53.33	20.00	25	71.42	1785.50
		0.5	86.66	96.66	83.33	73.33	70.00	46.66	10.00	25	66.66	1666.50
Polyethylene coated	5%	1.5	83.33	100.00	96.66	91.33	90.00	50.00	10.00	25	74.76	1869.50
		1.0	80.00	100.00	96.66	80.00	80.00	33.33	10.00	25	68.57	1714.25
		0.5	66.66	93.33	90.00	70.00	70.00	26.66	3.35	25	60.00	1500.00
Without coating	3%	1.5	90.00	100.00	100.00	100.00	86.66	36.66	0.00	19	85.55	1625.51
		1.0	73.33	100.00	100.00	93.33	80.00	33.33	0.00	19	79.99	1519.81
		0.5	43.33	93.33	86.66	66.66	70.00	33.33	0.00	19	65.55	1245.45
Encapsulated (Proprietory)	3%	1.5	76.66	96.66	93.33	80.00	96.66	33.33	0.00	19	79.44	1509.36
		1.0	73.33	93.33	83.33	80.00	73.33	30.00	0.00	19	72.22	1372.18
		0.5	66.66	93.33	80.00	76.65	56.66	26.66	0.00	19	66.66	1266.54

P = period up to which toxicity persisted, T = Average toxicity, PT = Index of persistent toxicity.

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ODONTOTERMES BRUNNEUS (HAGEN) (TERMITIDAE : ISOPTERA) AS A NEW PEST OF MAIZE AND GROUNDNUT

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Odontotermes brunneus Hagen was recorded as a new pest of both maize and groundnut in agricultural fields surrounding Warangal (Andhra Pradesh). It's damage to the crop plants are described in detail. The assessment of the loss of plants per acre due to the termite damage in both the maize and groundnut fields revealed that there was 40 5 per cent loss per acre during the kharif crop and 19.6 per cent loss per acre during the rabi crop in maize, and 7.7 per cent loss per acre in groundnut crop.

(Key words: *Odontotermes brunneus*, maize, groundnut)

Maize *(Zea mays* L.) and groundnut *(Arachis hypogaea* L,) are two important crops in tropical countries cultivated in kharif/rabi and kharif respectively in Telengana, the semiarid region of Andhra Pradesh (India). These are damaged by various species of termites in different zoogeographical regions (Harris, 1969; Wood *et al.*, 1980). In Telengana, the termites belonging to the genus *Odontotermes* have been reported damaging the groundnut crop in the farm of ICRISAT (Patancheru, A P) (Anon, 1983). However, little information is available on any specific termite infesting either the groundnut or maize crop. Moreover, Telengana is *terra incognita* as far as its termite fauna is concerned (Bose, 1984). Thus, the present investigation was undertaken during 1985 to find out the different species of termites damaging these crop plants in the agricultural fields surrounding Warangal (Latitude, 18° 0′ 31″; longitude 79° 29′ 5″ and altitude Ca. 263.7 m MSL). The termite which severely damaged the crops was collected and identified as *Odontotermes brunneus*

(Hagen). This report describes, incidentally for the first time, the pest status of *O. brunneus* and it's damage to the crops.

O. brunneus (Hagen) as a pest of maize :

O. brunneus, although was observed in the field foraging on the previous years left–over maize–litter consisting of stem and root pieces, no damage was recorded to the seeds and seedlings during the first four weeks of the crop. However, it attacked the stem of the maize plant at the ground level covering with earthen–sheet upto 10 cms height from the base during the tenth week. When the earthen–sheet was removed to examine the damage, a hole was found at the base on one side of the stem adjacent to the root leading to the middle pith of the stem, which was completely eaten a few cms upwards and downwards and filled with soil. However, the outer covering of the stem remained intact. During the twelfth week of the crop, some of the plants were found covered with earthen–sheet upto 40 cms. These severely

Fig. 1a Maize plant with cob, damaged
severely *O. brunneus* being lodged on
the ground.

Fig. 1b A cob partially damaged by *O. brunneus*

damaged plants were lodged on the ground (Fig. 1a) even by slightest wind, which were further damaded under the cover of earthen–sheet. In these plants, not only the stem and leaves were eaten but also the cobs and their seeds were damaged by the termite (Fig. 1b). The seeds in the cobs were eaten from the inner side leaving the outer seed-covering intact.

The percentage loss of maize plants per acre by *O. brunneus* is presented in Table 1, which reveals that more than 20 per cent of the plants were damaged severely being lodged on the ground, and another 19 percent of the plants were only attacked by the termite being covered by earthen–sheet, during kharif season. In the rabi season, the damage was comparatively less. It has been observed that the locations of the fields with $36.5 \pm 3.2\%$ soil–moisture content had more termite activity and termite–damaged plants than those with $26.0 \pm 8.4\%$ soil–moisture content, which had no termite activity

Three species of termites viz., *O. obesus* (Rambur), *O. gurdaspurensis* Holmgren et Holmgren and *Microtermes obesi* Holmgren have been reported as pests of maize in India (CHHOTANI, 1980). WOOD *et al.*, (1980) recorded *Microtermes* sp. attacking the maize plants during the tenth week. The percentage loss of plants by the *Microtermes* sp. was more i. e., 46 per cent compared to that of *O. brunneus* recorded during the present study. However they did not record any damage to seeds and seedlings in the beginning of the crop which is in consistence with the present findings.

TABLE 1. Percentage (mean ± S E) loss of maize plants per acre, due to the damage of *O. brunneus* Hagen.

Type of crop	severely damaged plants*	less severely damaged plants**
Kharif crop	21.2 ± 7.7	19.3 ± 4.4
Rabi crop	9.9 ± 1.2	9.7 ± 2.6

*Damage to the stem at the base leading to it's detachment from the root, and lodging of the plant on the ground.

**Damage to the stem being covered with earthen-sheet, and no lodging of the plant on the ground.

O. brunneus (Hagen) as pest of groundnut :

In the case of groundnut no damage was recorded to either seeds or seedlings by the *O. brunneus* during the first five weeks although the termites were recorded in the root zone of the plants. However, during the seventh week the termite attacked the plants covering the stem with earthen-sheet upto 5 cm height from the surface of the ground. It bored into the main stem just close to the ground level and tunneled down into the tap root and up into the stem (Fig. 2a). It damaged the pegs as well and scarified the mature pods (Fig. 2b) occassionally penetrating into their shells. The damage to pegs led to their breaking during harvesting, thus leaving the pods in the ground, CHHOTANI (1980) reported two species of termites viz., *O. obesus* and *O. wallonensis* (Wasmann) damaging groundnut in India.

The loss of plants due to the damage of *O brunneus* was estimated and found 7.7 ± 0.5 per acre. *O. obesus* has been reported to cause heavy plant mortality

Fig 2a Stem and root of groundnut plant tunneled and damaged by *O. brunneus*.

Fig. 2b Pods scarified by *O. brunneus* and the undamaged normal ones.

i.e., 35 percent in Madhya Pradesh (India) (RAWAT *et al.*, 1970). It was observed that more plants were attacked in localities of the fields with soil-moisture content varying from 13 to 16% compared to those with soil-moisture content varying from 5 to 11% where there was no termite activity. Though there was no direct information on the relationship of soil-moisture content of the field and the termite damage to the groundnut plants, a significant relationship has been recorded between the rainfall and *Microtermes* sp. infestation to groundnut (JOHNSON *et al.*, 1981).

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THE INTRINSIC RATE OF NATURAL INCREASE OF THE CABBAGE APHID, *BREVICORYNE BRASSICAE* (LINN.) (HOMOPTERA : APHIDIDAE) ON CAULIFLOWER

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The life and fertility tables were constructed for the cabbage aphid, *Brevicoryne brassicae* under laboratory conditions on 6-7 weeks old cauliflower plants. The cohort had the maximum longevity of 33 days and the maximum period of reproduction was 15 days. The maximum average production of progeny was 5.75 nymphs per female per day on the 22nd and 25th day of life span. The species had the true generation time (T) of 21.711 days during which it multiplied 49.80 times (Ro). The intrinsic rate of natural increase (rm) was 0.179 per female per day and the populations doubled in 3.87 days. The finite rate of increase (λ) was 1.196 i.e., the species multiplied 1.196 times per day.

(Key words: intrinsic rate of natural increase (rm), finite rate of increase (λ), true generation time (T), net reproductive rate (Ro), *Brevicoryne brassicae* cohort).

INTRODUCTION

The intrinsic rate of natural increase (rm) can be used for gaining useful insight into the population dynamics of a species. This information can be used as an index of rate of population growth in a particular environment and potential effectiveness of a natural enemy (MESSENGER, 1964 a). The possibility of determining overall mortality in aphid populations by measuring the difference between the potential rate of increase and observed increase was also discussed by HUGHES (1962, 1963). The objective of the present study was to determine the intrinsic rate of increase of cabbage aphid, *Brevicoryne brassicae* (Linn.) on

cauliflower *(Brassica oleracea* var *botrytis* L.). This aphid is the predominent species infesting cauliflower grown for seed production in north west Himalayas (BHALLA & PAWAR, 1977; KOTWAL *et al.*, 1985). Various aspects of the population dynamics of this aphid have been studied in laboratory and field conditions (MAC GILLIVRAY & ANDERSON, 1958; HUGHES, 1963; DAIBER, 1970; RAWORTH, 1984). However, previous demographic studies of this aphid were carried out on cabbage or other brassicas (LAMB, 1961; DE LOACH, 1974) under constant or fluctuating temperatures. In the present study, a population of *B. brassicae* was maintained on 6—7 weeks old cauliflower plants grown at room temperature; a condition more close to the field.

MATERIALS AND METHDOS

The observations were made under laboratory conditions where temperature varied

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from 14.0 to 21.0°C during February—March, 1984, the period of peak activity of *B. brassicae* in the field (TANDON *et al.*, (1977). Five to six seedlings of cauliflower (cv. Snowball-16) were raised in 15 cm × 15 cm plastic greenhouse pots in the laboratory. After 4 weeks of growth the plants were thinned to a single plant per pot. The plants were subirrigated daily and were allowed at least 6—7 weeks growth before the start of the experiment.

The test aphids were obtained from a laboratory clone maintained on cauliflower. Before the experiment, 2 adult apterous virginoparae were placed in a clip-on micro-cage similar to that described by NOBLE (1958) on a fully expanded leaf on each plant, and allowed to lay young ones for about 24 hours. At the end of this period, the adults and all but one nymph were removed which was allowed to develop and form adult. In all 20 such sets were maintained initially but the observations were recorded only on 10 randomly selected aphids which formed a cohort. The observations were started as soon as the adults started larvipositing and ended with the death of the last aphid. New born progeny were removed daily after each counting in order to avoid any possible effect of crowding on reproduction. Before moving an aphid, it was prodded gently until it withdrew its stylets.

The age-specific survival (lx) and age-specific fecundity (mx) at each pivotal age (x) were worked out daily for the entire reproductive period, to prepare the fertility table as per method outlined by BIRCH (1948). The net reproductive rate (Ro), approximate generation time (Tc) and capacity for increase (rc) were calculated. However, as pointed out by SOUTHWOOD (1976), for insects exhibiting overlapping generations, the intrinsic rate of natural increase (rm) is slightly higher than the capacity for increase (rc). The correct value of rm was found by taking two arbitrary trial values on either side of the value for rc, differing only in the second decimal place, and substituting them in the formula until the two values of the equation $(e^{7-rmx}lxmx)$ were found which lay immediately above or below 1096.6. The two values of $e^{7-rmx}lx$ mx were then plotted on the X-axis against their respective rm's on the Y-axis. The two points were joined to give

a line which intersected a vertical line drawn from the desired value of 1096.6. The point of intersection gave the value of rm accurate to three decimal places as suggested by WATSON (1964). The true generation time (T) and finite rate of increase (λ) were further calculated. Also, time taken (in days) to double the population was calculated by the formula:

$$\text{Days} = \frac{\log_e 2}{rm}$$

RESULTS AND DISCUSSION

The data on the reproductive potential of *B. brassicae* on cauliflower plants are presented in Table 1. It is revealed that during February–March the maximum longevity of the reproducing female was 17 days and the maximum period of reproduction was 15 days. There was 100 per cent survival at the time mother aphid started producing nymphs but the survival rate decreased after 10th day of reproduction. The aphid started producing young ones on the 17th day with a mean production of 4.75 nymphs/female/day. The maximum average number of progeny was produced on the 22nd and also on the 25th day of life span. The mean number of progeny produced per female over the entire reproductive period was 53.75. The net reproductive rate or the net replacement rate (Ro) was calculated to be 49.80. This small variation can be explained on the basis of decrease in survivorship value (lx) for the parent females most of which died earlier than the maximum life span of 33 days. The species had an approximate generation time (Tc) of 22.994 days and true generation time of 21.711 days. The aphid would thus multiply 49.80 times in a single generation occupying 21.711 days.

The cohort had the capacity for natural increase (rc) as 0.169 whereas,

TABLE 1. Life table statistics of *B. brassicae* on cauliflower in the laboratory during February—March.

Pivotal age (days)	Proportion of live at age x	No. of female progeny/ female			Trial rm	
					0.16	0.18
x	lx	mx	lxmx	x lxmx	7−rmx e lxmx	7−rmx e lxmx
0—16	1.00	Immature stages				
17	1.00	4.75	4.750	80.750	343.142	244.238
18	1.00	3.00	3.000	54.000	184.668	128.845
19	1.00	3.00	3.000	57.000	157.372	107.620
20	1.00	3.25	3.250	65.C00	145.279	97.383
21	1.00	2.75	2.750	57.750	104.753	68.827
22	1.00	5.75	5.750	126.500	186.643	120.205
23	1.00	4.25	4.250	97.750	117.555	74.211
24	1.00	3.25	3.250	78.000	76.604	47.402
25	1.00	5.75	5.750	143.750	115.492	70.049
26	1.00	4.75	4.750	123.500	81.300	48.334
27	0.80	5.25	4.200	113.400	61.258	35.698
28	0.80	2.75	2.200	61.600	27.343	15.618
29	0.70	2.00	1.400	40.600	14.827	8.302
30	0.50	2.00	1.000	30.000	9.025	4.953
31	0.40	1.25	0.500	15.500	3.845	2.068
32	0.20	0.00				
33	0.20	0.00				
34	0.00					
Total		53.75	49.800	1145.100	1629.106	1073.753

the true intrinsic rate of increase, determined graphically (Figure 1), was 0.179. This value of rm was higher than 0.134 reported by DE LOACH (1974) at the constant temperature of 20°C when *B. brassicae* was reared on cabbage. The difference may be attributed, besides characteristics of the aphid clones and the host plant species used, to the effect of fluctuating temperatures which is known to stimulate the rate of development (CLOUDSLEY-THOMPSON, 1953). In aphids, this phenomenon has been investigated by MESSENGER (1964 b) and by SIDDIQUI *et. al.* (1973). both of whom obtained slightly faster development with
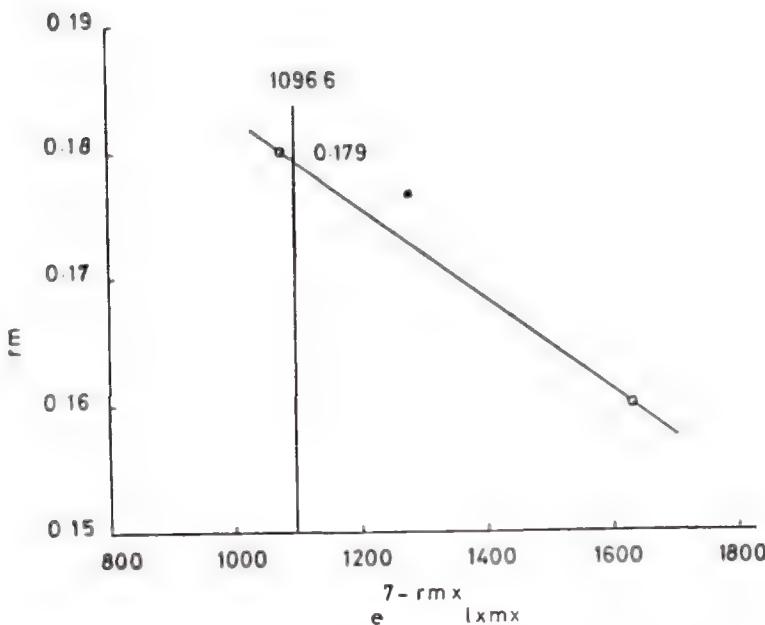
Fig. 1. Determination of true instrinsic rate of increase in experimental *B. brassicae cohort*.

fluctuating temperatures. Under existing conditions the populations of *B. brassicae* would double in 3.87 days. The species had the finite rate of increase (λ) as 1.196, which means that the population would multiply 1.196 times per day at temperature fluctuating between 14.0 to 21.0°C during February–March. These results reaffim many earlier estimates of high biotic potential of this aphid (LAMB, 1961; HUGHES, 1963; DE LOACH, 1974; RAWORTH; 1984).

The information on demographic parameters of *B. brassiicae* obtained in the present findings is of much practical use since it relates to the speed of increase of population and not the individual factors producing it (longevity, survival and fecundity). The results would provide basis for future study of factors regulating populations in the field, in which the overall mortality in the population can be determined by measuring the difference between the potential rate of increase and the observed rate of increase in the field.

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EFFECT OF TWO GRNULAOSIS VIRUSES ON THE SILKWORMS, *BOMBYX MORI MERIDIONALIS* F. AND *PHILOSAMIA RICINI* B.

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The safety of two granulosis viruses, one infecting sugarcane shoot borer, *Chilo infuscatellus* Snellen and the other infecting sugarcane internode borer, *Chilo sacchariphagus indicus* (Kapur), was tested by food contamination method to mulberry silkworm, *Bombyx mori meridionalis* F. and eri silkworm, *Philosamia ricini* B. Both the species of silkworms, when fed with doses approximately 100 times of the recommended dose for pest suppression, were not killed due to virus infection. There was no variation in cocoon weight, per cent adult emergence, sex ratio and fecundity. Histopathological examination also failed to show the multiplication of the viruses in the body of the test insects.

(Key words: granulosis virus, silk worms)

INTRODUCTION

Insect viruses, especially baculoviruses, are considered as potential tools in pest management programmes. Recently, two granulosis viruses (GVs) were reported, one infecting sugarcane shoot borer, *Chilo infuscatellus* Snellen (Easwaramoorthy & David, 1979) and the other infecting internode borer, *Chilo sacchariphagus indicus* (Kapur) (Crambidae : Lepidoptera) (Mehta & David, 1980), and were found to be widely distributed in Tamil Nadu and Pondicherry in India (Easwaramoorthy & Jayaraj, 1986a). The GVs, especially that of *C. infuscatellus*, were found to offer good scope in the suppression of the pests under field conditions (Easwaramoorthy & Jayaraj, 1986b). These GVs

when recommended for large scale field use, there is a chance for silkworms to be indirectly exposed to these viruses through contaminated food. Hence, in the present study, the effect of these viruses on the widely reared mulberry silkworm, *Bombyx mori meridionalis* F., and a less important eri silkworm, *Philosamia ricini* B., which is commonly reared in Assam and West Bengal, was investigated.

MATERIALS AND METHODS

i) *Virus suspensions*

The two granulosis viruses were harvested from larvae of *C. infuscatells* and *C. sacchariphagus indicus* killed in the laboratory by GV. The virus suspensions were purified several times using alternate cycles of low (500 rpm) and high speed (10,000 rpm) centrifugation. Finally the virus was sedimented by centrifugation at 17,000 rpm for 30 min. at 5°C in a refrigerated centrifuge. Counting of inclusion bodies (IBs) was done using a

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Petroff Hauser and Helber counting chamber with 0.02 mm depth under a phase contrast microscope and number of IBs in original stock suspension was calculated using the formula given by KOLMER & BOENER (1945).

ii) *Test with mulberry silkworm*

Second instar larvae of multivoltine strain of *B. mori meridionalis* obtained from the Central Sericultural Training Centre, Coimbatore, was used in this study. Mulberry leaves dipped in 1.1×10^{10} IBs/ml (recommended dose for field application is 1×10^{7} IBs/ml) of shoot borer or internode borer GV along with the surfactant, Teepol (sodium secondary-alkyl $(C_{10} - C_{18})$ sulphate) 0.05 per cent. The larvae just resumed feeding after the first moult were allowed to feed for 10 feedings on these leaves for the first two days. Then the larvae were provided with untreated mulberry leaves. Suitable control was also maintained. Each treatment was replicated five times with 25 larvae per replication. When the larvae started spinning cocoons they were transferred to *'Chandraki'*.

Data were collected on larval mortality, fresh weight of cocoons, per cent adult emergence and sex ratio. The mean fecundity

was worked and by dissecting out females on the day of their emergence. The body contents of the dead larvae were also examined microscopically for the presence and/or multiplication of the viruses.

iii) *Test with eri silkworm*

The culture of *P. ricini* obtained from Bhabha Atomic Research Centre, Bombay was used in this study. The larvae just resumed feeding after first moult were fed on castor leaves dipped in virus–Teepol mixture as described above for two days. The larvae in control were allowed to feed on castor leaves dipped in distilled water mixed with teepol 0.05 per cent. Observations were made as done for mulberry silkworm. The mean fecundity was determined by allowing the mated females to lay eggs on butter paper.

RESULTS AND DISCUSSION

There was no mortality of mulberry and eri silkworm larvae due to virus treatment when they were fed with shoot borer- or internode borer GV. The per cent larval survival, cocoon weight, pupal period, adult emergence, sex ratio and

TABLE 1. Effect of oral feeding of two granulosis viruses on mulberry and eri silkworm.

Characteristics	mulberry silkworm			eri silkworm		
	shoot borer virus fed	internode borer virus fed	untreated check	shoot borer virus fed	internode borer virus fed	untreated check
Per cent mortality due to virus infection	0.0	0.0	0.0	0.0	0.0	0.0
Per cent larval survival	80.0[a]	64.0[a]	66.7[a]	80.0[g]	80.0[g]	77.0[g]
Average cocoon weight (g)	1.46[b]	1.43[b]	1.50[b]	2.16[h]	2.13[h]	2.19[h]
Mean pupal period (days)	16.8[c]	16.3[c]	16.9[c]	19.6[i]	20.1[i]	19.8[i]
Per cent adult emergence	97.3[d]	96.8[d]	97.2[d]	98.7[j]	98.4[j]	98.6[j]
Sex ratio (F : M)	1 : 1.5[e]	1 : 1.4[e]	1 : 1.5[e]	1.44 : 1[k]	1.67 : 1[k]	1.45 : 1[k]
Mean fecundity	550.0[f]	522.0[f]	522.0[f]	160.6[l]	153.9[l]	156.6[l]

The figures followed by the same letters are not significantly different by DMRT test.

fecundity were not altered in the two virus treatments compared to untreated check (Table 1) indicating the non–infective nature of both the viruses to mulberry and eri silkworms. Histopathological examination also failed to show either the presence or multiplication of these viruses in their body.

Earlier VASILJEVIC (1968) reported that there was no mortality of *B. mori* when fed with *Hyphantria cunea* (Drury) GV. The GV of *Pieris rapae* (Linn.) also failed to show any ill effects on *Bombyx* spp. (ANON., 1980). The nuclear polyhedrosis virus of *Mythimna separata* Wlk. was also found safe to *B. mori* (DHADUTI & MATHAD, 1980).

The present study clearly indicated that even when the silkworms, by chance, are exposed to high doses of these two GVs, there occurs no adverse effect.

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HISTOPATHOLOGICAL EFFECTS OF SOME INSECTICIDES
ON THE OVARIES OF MELOID BEETLE,
MYLABRIS PUSTULATA

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The ovaries of *Mylabris pustulata* are acrotrophic type. On the basis Of histological characters of developing oocytes and follicular epithelium, oocyte development is divided into five stages. Anomalies in the histological structure become well evident after the treatment of insects with SAN-322 and DDVP. Vacuolation within yolk, distorted shape of oocytes, pycnosis or condensation of oocyte nucleus and necrosis of follicular epithelium are the common findings.

(Key words: Mylabris pustulata, SAN 322, DDVP)

INTRODUCTION

Although LANGE & KREUGER discovered the biological activity of organophosphorus esters for the first time in 1932, practical development of these compounds as insecticides is mainly due to the work of SCHRADER and his associates beginning in 1937. Since then a large number of compounds have been developed and several workers have studied insecticidal effects on the life cycle, fecundity and fertility of insects. But the gross pathologies generally have received so little attention that our knowledge of them is very scanty. Therefore, the present investigation has been undertaken to study some of the pathological effects on the ovaries resulted after the treatment of SAN 322 and DDVP.

MATERIAL AND METHODS

Adult female meloid beetles, *Mylabris pustulata* were collected locally and grouped according to their weight. The insecticides used in this investigation were SAN 322 (Blotic

Sandoz, India common name, Propetamphos and DDVP Technical (Ciba Geigy). Two concentrations of these insecticides viz., 0.1% and 0.01% were prepared in acetone. The solution thus prepared was poured in petri dish with a radius of 5 cm. The dish was rinsed with the solution and kept aside till the evaporation of acetone. An evenly spread layer of residue ramained on the surface of petri dish. A number of petri dishes layered with specific concentration of specific chemical were prepared for treatment. Five females from each group of weighed beetles were released in the petri dish and after five minutes removed to the clean specimen bottles. The same procedure was repeated every time. Acetone treated females were considered as controls.

Moribund females were dissected out in Ringer's solution. Ovaries were fixed in aqueous Bouin's fixative and processed for histological preparations in a routine manner. The sections were stained by iron haematoxylin–orange G (HUMASON, 1972).

RESULTS AND DISCUSSION

Histology of normal ovarian development

The ovarioles are acrotropic type and can be differentiated into various

zones described in a typical insect ovary (SNODGRASS, 1935). The vitellarium usually contains three egg follicles. On the basis of histological characters of the developing oocytes and follicular epithelium and also on membrane formation and yolk deposition, oocyte development in *M. pustulata* is divided into 5-stages which are summarized in Table 1, viz., stage-1 avitellogenic; stage-2 early vitellogenic; stage-3 mid-vitellogenic; stage-4 late vitellogenic and stage-5 maturation (Figs. 1–7).

These obsesvations are in accordance with the findings of SIDHRA *et al.* (1984),

## Histopathological changes in the ovaries of treated beetles

Alterations in the histological structure of oocytes become well-evident in the ovaries of insects treated with both the organophosphorus insecticides. Some prominent deformities are cited (Table 2; Figs. 8–23). The type and degree of effect mainly depend upon the stage of oocyte development. Since the germ cells are the most sensitive cells, striking degenerative changes are observed in the germarium in both the cases.

Here, contact between an insecticide and insect is through cuticle, then it

TABLE 1. Characterisation of oocyte development in the beetle, *M. pustulata* in terms of gross morphology.

| Stage	length (L) and width (W) of terminal oocyte follicle (mm)	cytological characteristics
Germarium		Contains germ cells and prefollicular tissue
1	L 0.07 ± 0.02 W 0.07 ± 0.01	OC—Spherical, after differentiation from germarium cyst takes lateral position, later on becomes arranged in linear fashion, nucleus centrally placed, spherical
		FE—Small cuboidal cells
2	L 0.18 ± 0.01 W 0.11 ± 0.01	OC—Ellipsoidal, yolk deposition initiated, nucleus centrally placed, oval
		FE—Columnar
3	L 0.58 ± 0.05 W 0.44 ± 0.01	OC—Accumulation of yolk globules, nucleus lifted upwards
		FE—Oval, with intercellular spaces
4	L 1.06 ± 0.01 W 0.36 ± 0.03	OC—Filled with yolk material, chorion formation begins
		FE—Oval, with intercellular spaces
5	L 1.08 ± 0.01 W 0.41 ± 0.04	OC—Attains maximum size, packed with yolk material enveloped in chorion.
		FE—Flattened, darkly stained

± Standard error, OC oocyte, FE follicular epithelial cells.

Figs. 1—7 Sections passing through the different parts of the ovariole showing normal oocyte development. Fig. 1. Ovariole showing terminal filament (TF), germarium (GR), developing oocyte (OC). × 100: Fig. 2. Magnified view of germaium (GR) and avitellogenic oocyte (OC), × 160; Fig. 3. Early vitellogenic oocyte. × 160; Fig. 4. Mid-vitellogenic oocyte. × 100; Fig. 5. Magnified view of Fig. 4. × 320; Fig. 6. Late-vite.logenic oocyte. × 320; Fig. 7. Maturation stage showing chorion formation (arrow). × 320.

Figs. 8—11. Sections through the ovaries of 0.1 per cent SAN-322 treated females. Fig. 8. Germarium with degenerating cells. × 160; Fig. 9. Avitellogenic oocyte showing displaced nuclei (arrow). × 160; Fig. 10. Early-vitellogenic oocyte showing disrupted FE and flowing ooplasm (arrow). × 100; Fig. 11. Late-vitellogenic oocyte with vecuolation within yolk and ill-defined FE. × 400. Figs. 12—15. Sections through the ovaries of 0.1 per cent SAN-322 treated females. Fig. 12. Germarium with condensed nuclei (GR) and avitellogenic oocyte (OC) with shrunk ooplasm. × 256; Fig. 13. Distorted tunica propria (TP) and gaps between FE and oocyte in early vitellogenic oocyte × 128; Fig. 14. Mid-vitellogenic oocyte with pycnotic nucleus and degenerating FE. × 320 Fig. 15. Mature oocyte showing resorption of yolk globules and necrotic FE. × 320.
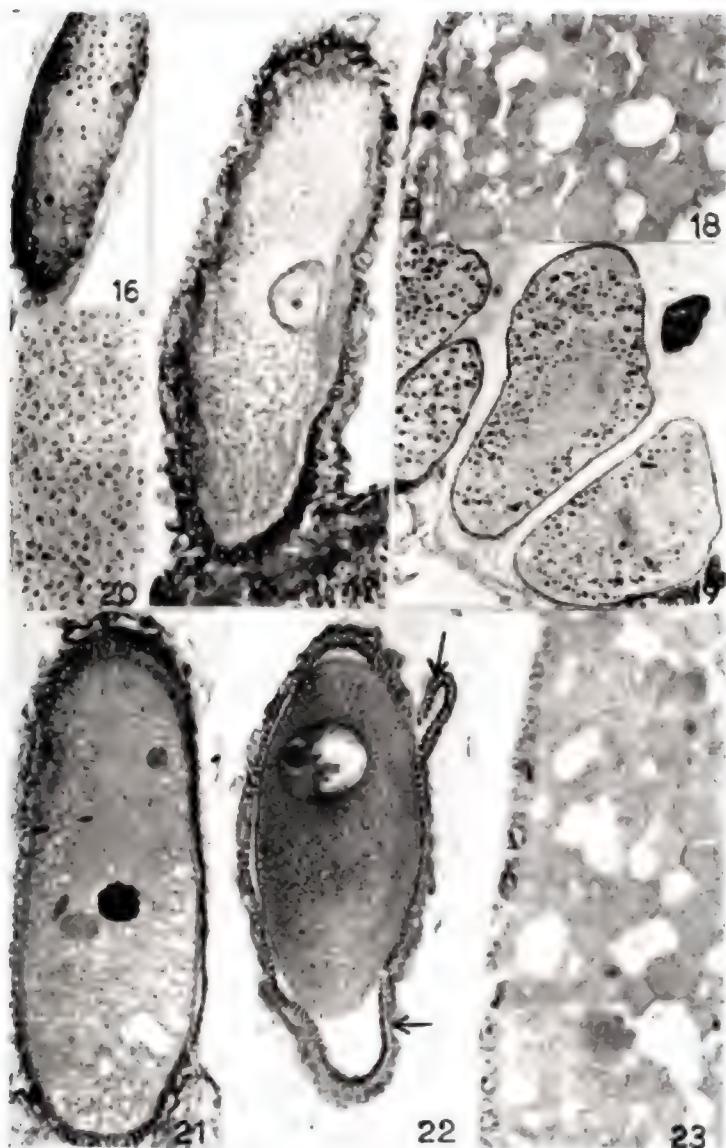
Figs. 16—19. Sections through ovarioles of 0.01 per cent DDVP treated females. Fig. 16. Germarium with degenerating cells. × 126; Fig. 17. Distorted early vitellogenic oocyte. × 160; Fig. 18. Vacuolation within yolk in the late vitellogenic oocyte. × 320; Fig 19. Distorted mature oocytes. × 50. Figs. 20—23. Sections through ovarioles of 0.01 per cent DDVP treated females. Fig. 20. Germarium showing cellular damage. × 100; Fig. 21. Vacuolation of nucleus and crypts in FE sheath in the early vitellogenic oocyte. × 100; Fig. 22. Early vitellogenic oocyte hsowing shrunk nucleus. × 128; Fig. 23. Vacuolation in the late vitellogenic oocyte. × 320.

TABLE 2. Some histopathological changes observed in the ovaries of meloid beetle, *M. pustulata* after insecticide treatment.

Stages	SAN-322		DDVP	
	0.1 per cent	0.01 per cent	0.1 per cent	0.01 per cent
Germ-arium	Degeneration of most of the tissue	Clumped chromatin and condensed nuclei.	Clumped chromatin mortification of tissue	Degeneration of germ cells and prefollicular cells
1	Displacement of oocyte nucleus. L 0.05 ± 0.03 W 0.04 ± 0.07	Shrunk ooplasm L 0.07 ± 0.01 W 0.1 ± 0.02	Irregularity in the shape of oocytes L 0.08 ± 0.02 W 0.1 ± 0.01	Patches in ooplasm L 0.07 ± 0.01 W 0.1 ± 0.02
2	Disruption of FE sheath resulting in the outburst of ooplasm	Formation of wide gaps between FE and ooplasm	Shrinkage of oocyte nucleus	Shrinkage and vacuolation of oocyte nuclei
	Patches in ooplasm	Distortion of tunica propria L 0.23 ± 0.04 W 0.11 ± 0.01	Distortion of oocyte	Crypt formation in FE sheath
	Indistinct FE L 0.25 ± 0.01 W 0.09 ± 0.01		Ill-defined tunica propria and FE L 0.28 ± 0.07 W 0.08 ± 0.05	Vacuolation in ooplasm L 0.29 ± 0.08 W 0.12 ± 0.05
3	Vacuolation within yolk	Displacement and pycnosis of oocyte nuclei	Vacuolation within yolk	Vacuolation within yolk
	Pycnosis and condensation of FE nuclei. L 0.49 ± 0.02 W 0.44 ± 0.05	Degeneration of FE. L 0.70 ± 0.04 W 0.40 ± 0.03	Resorption of FE L 0.98 ± 0.01 W 0.43 ± 0.03	Degeneration of FE L 0.84 ± 0.03 W 0.53 ± 0.02
4	Vacuolation within yolk	Uneven distribution of yolk globules	Vacuolation within yolk globules	Resorption of yolk globules
	Ill-defined FE L 0.59 ± 0.01 W 0.32 ± 0.01	Degeneration of FE L 1.01 ± 0.03 W 0.42 ± 0.03	Necrosis of FE L 1.1 ± 0.02 W 0.5 ± 0.03	Degeneration of FE L 1.2 ± 0.01 W 0.56 ± 0.04
5	Vacuolation and resorption of yolk	Resorption of yolk globules	Vacuolation and resorption of yolk	Resorption and vacuolation of yolk
	Mortification of FE L 0.55 ± 0.01 W 0.32 ± 0.03	Necrosis of FE L 1.18 ± 0.05 W 0.38 ± 0.04	Necrosis of FE L 1.4 ± 0.04 W 0.56 ± 0.09	Complete degeneration of FE L 1.5 ± 0.04 W 0.56 ± 0.03

$\pm$ standard error, FE follicular epithelium, L length of oocyte (mm), W width of oocyte (mm)

enters the insect haemolymph which plays an important role in transport of insecticides to various parts of the organism (BURT *et al.*, 1971). Thus, anomalies observed in the ovaries of all treated beetles such as vacuolation, degeneration and resorption of the oocytes and yolk material as well as degeneration and necrosis of follicular epithelium might be the cytotoxic effects of SAN–322 and DDVP, since ovaries are constantly bathed in the haemolymph. In addition to direct toxic effects on cells, these alterations may also be due to malfunctioning of some physiological process.

The reasons for the formation of gap between the follicular epithelium and yolk appears to be due to contraction of ooplasm from peripheral epithelial cells and inhibition of yolk formation. VISHWANATH *et al.* (1976), while working with chemosterilant have expressed similar opinion regarding gap formation in *Locusta migratoria.*

In the present investigation administration of 0.1 per cent SAN–322 showed significant decrease in size of oocytes at all stages of development except the length of early vitellogenic oocyte. On the contrary, treatment with 0.1 per cent SAN–322 and 0.1 and 0.01 per cent DDVP treatment resulted in remarkable hypertrophy. The crypt formation in follicular epithelial sheath may also be due to hyperplasia of epithelial cells. There have been many studies dealing with such effects of antithyroid drugs on the thyroid glands in vertebrates. BARRINGTON & MATTY (1955) reported final atrophy of the thyroid gland in *Phoxinus phoxinus* followed by hypertrophy and hyperplasia after immersion in 0.03

per cent thiouracil solution. The hypertrophy and hyperplasia observed in the present study may lead to the atrophy of these cells.

Mutagenic effects of organophosphorus insecticides have been reported by FISHBEIN (1976) which indicate that nuclei are affected by these compounds. Pycnosis, vacuolation, condensation of nuclei and clumping of chromatin material observed in this study may support the above view.

Thus it can be concluded that both insecticides have similar mode of action and produce cumulative histopathological effects in the ovaries of *M. pustulata.*

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EFFECT OF ETHYLMETHANE–SULPHONATE (EMS) ON THE REPRODUCTIVE POTENTIAL OF FRUIT FLY, *DACUS DORSALIS* HENDEL (DIPTERA : TEPHRITIDAE)

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In the present study, an attempt has been made to study the sterilant effects of ethylmethane-sulphonate on *Dacus dorsalis.* It was observed that aqueous as well as acetone solutions of EMS induced significant sterility in both sexes of fruit fly, but in comparison aqueous EMS is more effective than acetone EMS. A significant increase and decrease in fecundity of females was observed in the mating combinations of T♂ X T♀ and T♂ X U♀ respectively with aqueous EMS. In the mating combinations where flies were treated with acetone EMS, although a significant decrease in fecundity was recorded irrespective of sex treated, subsequently per cent egg hatch remained higher affecting fertility to a lesser extent. It was also observed that in the mating combinations where males were treated, corrected per cent sterility is more irrespective of the solvent used in solution preparation showing more sensitivity of males towards EMS treatment than females.

(Key words: sterilant effect, ethylmethane sulphonate, *Dacus dorsalis)*

INTRODUCTION

The mutagenic effects of sulphonates have been investigated in several animal and plant species. Some of them caused breaking of chromosomes (MOUTSCHEN, 1965), while others (isopropyl methane-sulphonate and methyl methanesulphonate) induced complete sterility and efficient structural changes in chromosomes of mouse (MOUTSCHEN, 1969a, b). In *Drosophila* sp. it has been observed that 0.45×10^{-2} M concentration of MMS is as efficient as 3500 r of X–rays for inducing lethal mutations (AUERBACH & ROBSON, 1947) *Dacus dorsalis*, commonly known as mango fruit fly, is a serious pest of mango and is widely distributed throughout India and in many parts of the world. Apart from mango it attacks a wide varieties of fruits and vegetables totalling about 250 hosts alone in Hawaiin Island (NARAYANAN & BATRA, 1960). Various methods including application of insecticides either in baits or as spray have been the principal control measures of this insect pest. Unfortunately, many difficulties arose in the application of insecticides including development of insecticidal resistance, environmental hazard, technical difficulties and high costs. An alternative method of pest control proposed by KNIPLING (1937) was adopted by many scientists. It includes rearing, sterilizing and then releasing the sterilized insects in natural population to compete with fertile insects. In the beginning successful sterilization of insect pests was achieved by gamma radiation, but it also caused many difficulties such

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as (i) damage to somatic tissues affecting the viability and sexual competitiveness, (ii) laborious and highly expensive process not to be used as common practical method and (iii) rapid mortality of sterilized insects. Therefore, sterilants were preferred to sterilize the insect pests. Sterilants can be sprayed directly in the field provided these should not have an adverse effect on other useful organisms. With a view to controlling this fruit fly through chemosterilants, a loboratory study was carried out to study the sterilant effects of EMS in *Dacus dorsalis*.

MATERIAL AND METHODS

In the present study, field collected flies reared in the laboratory under controlled conditions of temperature and humidity as described earlier (THAKUR & KUMAR, 1984). The sample of EMS was obtained from Eastman Kodak Co. Rochester, New York, U S A. Solutions of EMS of different concentrations were prepared just before use on weight to volume basis in water as well as in acetone. Newly ·emerged flies (0–24 h old) were first im-·mobilized by chilling treatment. The chilled flies were easier to handle and mortality was not a factor. To the chilled flies one microlitre solution of test compound per fly was applied topically on the ventral surface ·of abdomen with the help of a micro-applicator. At maturity different mating combinations (T♂ × T♀, T♂ × U♀, U ♂ × T♀, & U♂ × U♀) (T = treated, U = untreated) were examined for fecundity of females and per cent egg hatch in each combination. Five replicates for each treatment were studied. Corrected per cent sterility in treated flies was calculated according to CHAMBERLAIN ·(1962) as follows :

$$\text{Corrected \% sterility} = \frac{\text{\% egg hatch in control} - \text{\% egg hatch in treatment}}{\text{\% egg hatch in control}} \times 100$$

The per cent fecundity was calculated asfollows :

$$\text{Per cent fecundity} = \frac{\text{Average eggs laid per treated female}}{\text{Average eggs laid per control female}} \times 100$$

The data obtained were analysed statistically by applying Duncan's new multiple range test (DUNCAN, 1955) after transforming the percentages into angles. Significance between any two treatments was ascertained at 5 and 1 per cent levels of significance.

RESULTS AND DISCUSSION

The results obtained are presented in Tables 1 and 2. The results indicate that aqueous as well as acetone EMS induced significant sterility in both the sexes of fruitfly. Similar results have been reported by MOUTSCHEN (1969 a, b) in mouse with isopropyl methanesulphonate and methylmethane-sulphonate. But contrary to the present findings THOMPSON & RODRIGUES (1979) did not observe any significant effects of EMS on eggs, pupae and adults of *Aedes aegypti* L. This contradiction may be due to specific action of EMS against a particular species of an organism. In similar way, busulfan was found to be an effective mutagen in adult *Musca domestica* (LACHANCE *et al.*, 1970), while not in adult *Diparopsis castanea* (CAMPION, 1970). Further, it was observed that aqueous EMS induced more sterility as compared to acetone EMS which is obvious from corrected per cent sterility. At the same concentration (10%) corrected per cent sterility in aqueous and acetone EMS are 42.4 and 22.52 respectively which is almost double in aqueous EMS. Induction of more sterility in aqueous EMS than acetone EMS may be due to either more compatibility of EMS in water than acetone or non–polarity of aqueous solution. It is a known fact that the penetration through cuticle is related to the polarity of compound and relatively non-polar substances penetrate to a greater extent than do the polar substances. Similar observations have been reported by

TABLE 1. Effects of aqueous EMS on the fertility of flies.

Conc.	mating combin- ations	pairs crossed	average eggs / female	% fecundity	% egg hatch	corrected % sterility
Control	U♂ × U♀	5	605a	100a	90.13a	———
10%	T♂ × T♀	5	687b	113.55b	51.91b	42.4
10%	T♂ × U♀	5	546.66c	90.36c	49.14b	45.47
10%	U♂ × T♀	5	642.33ab	106.17ab	66.16c	26.59

The figures in a column not sharing the common letter are statistically significantly different from one another according to Duncan's new multiple range test with ∝ = 0.05.

TABLE 2. Effects of acetone EMS of the fertility of flies.

Conc.	mating combin- ations	pairs crossed	average eggs/ female	% fecundity	% egg hatch	corrected % sterility
Control	U♂ × U♀	5	683.75a	100a	86.8a	———
10%	T♂ × T♀	5	540.5b	79.04b	67.25b	22.52
20%	T♂ × T♀	5	402c	58.79c	67.62b	22.09
20%	T♂ × U♀	5	400.5c	58.57c	68.85b	20.67
20%	U♂ × T♀	5	397.5c	58.13c	72.2b	16.81

The figures in a column not sharing common letter are statistically significantly different from one another according to Duncan's new multiple range test with ∝ = 0.01.

SEAWRIGHT *et al.* (1971, 1973). In the mating combinations where both sexes were treated with aqueous EMS, a significant increase in fecundity of female flies was observed, but subsequently per cent egg hatch was significantly reduced. In the mating combinations where only males were treated a significant decrease in fecundity of female flies was observed. The increased fecundity may be due to (i) direct effect of EMS on accessory glands of treated female flies responsible for egg production (ii) accumulation of more chemical (EMS) in females as the transfer of chemical takes place from males to females during mating (iii) more penetration of non–polar solution through cuticle affecting accessory glands of females to a greater extent. Similar results have been reported by CAMPION (1970, 1971) and BALL & PAULJNA (1979), who observed that hyperactivity of accessory glands is responsible for increased fecundity. In conformity with our findings, KUIPERS (1962) and RAMADE (1967) suggested that increase and decrease

in fecundity is correlated with increase and decrease in neurosecretion which may be affected by treatment. Also it was observed that in mating combinations where males were treated, corrected per cent sterility is more irrespective of the solvent used for solution preparation. This indicates that males are more sensitive to EMS than females. This may be due to the immature stages of ovaries at the time of treatment which were affected to a lesser extent. In the fly under study, either the testes of males are mature at the time of flies, emergence (presence of mature sperms in testicular tubes) or get maturation soon after emergence, while ovaries get maturation (presence of eggs in ovarioles) 10–13 days post emergence. It has been stated by some researchers that sperms already present in testes at the time of treatment are highly sensitive to chemicals and gonadial cells appear less susceptible and eventually there was resumption of fertility, while others claimed that gonadal cells were more susceptible and there was progressive testicular/degeneration and resorption (LABRECQUE & FYE, 1978). There are also several other workers (KEISER *et al.* 1965; GROVER *et al.* 1979; THAKUR & MANN, 1981) who observed that males are sterilized at lower doses and are more sensitive than females.

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IDENTIFICATION OF SOME INDIAN PYRAUSTINAE (LEPIDOPTERA : PYRAUSTIDAE)

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Genitalial morphology of 16 species of Pyraustinae belonging to 14 genera were made. All the species showed a general resemblance in the overall morphology of genitalic parts. Modifications in the structural morphology of uncus in the male genitalia appeared to be useful in the segregation of these moths at the generic level while that of other parts like valvae, phallus, saccus and bursa were useful at specific levels. An identification key based on genitalic characters was prepared for the easy identification of these moths.

(Key words: Lepidoptera, Pyraustidae, Pyraustinae)

The Pyraustinae form an economically important group of Lepidoptera characterised by the presence of a well developed proboscis and the free origin of the forewing veins 7 and 10 from the cell. Segregation of moths belonging to this family upto the generic level is possible using the scheme proposed by Hampson (1896). However, specific determination is difficult in the absence of a proper identification key and one has to go through the elaborate species descriptions given by Hampson (1896). Recent studies by several workers (Munroe 1960, 1969, 1970; Pajni & Rose, 1977; Mathew & Menon 1986 a, b, c) have shown the importance of genitalic structures in the classification of this group of insects. In this work, morphology of the external genitalia of 16 species of Pyraustinae collected from Kerala were studied. For description of parts, we have followed the terminology given by Klots (1970).

The genitalial morphology of species studied herein are discussed below:

1. Cirrhochrista fumipalpis
Felder (Figs. 1, 17)

Male–Uncus spatulate, borne on a long stalk. Posterior end of tegumen flat. Gnathos forming a pointed elongate process. Vinculum much broader than long. Valvae broad at the apex, thickened at the costa. A long stout spine–like process arising from the harpe, and below this a slender process covered with hairs. Sacculus with a rhomboidal sclerotized spot.

Phallus long and tubular, slightly expanded at both ends. Cornuti composed of two, long bar–like sclerotized processes, one pointed and the other spatulate.

Female–Bursa globular, signum composed of stout spine–like process having a broad base and expanded into a transversely oval process. Ductus long, expanded distally, into which opens a fine duct from the receptaculum seminis. Posterior apophyses short. Ovipositor short.

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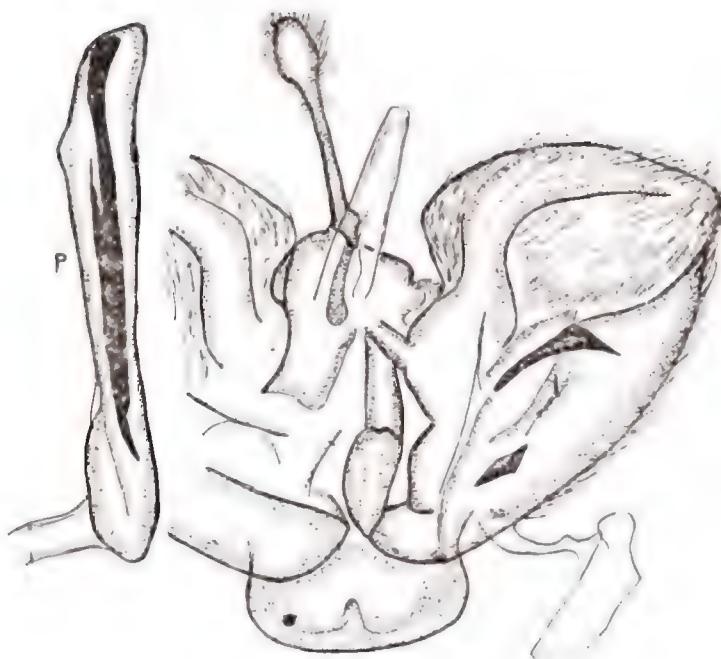
Fig. 1. Male genitalia of *Cirrhochrista fumipalpis*.
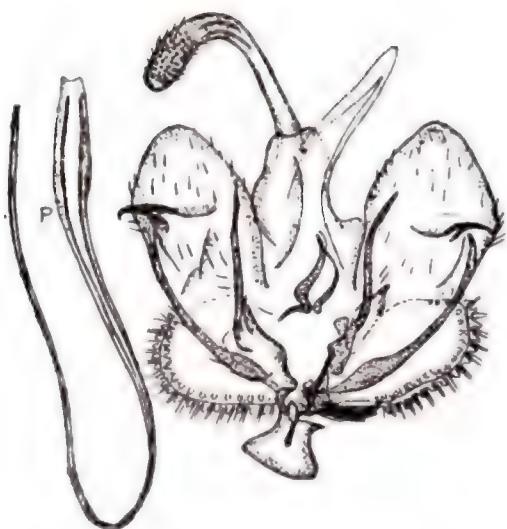
Fig. 2. Male genitalia of *Tulanga sexpunctalis*.

Fig. 3. Male genitalia of *Piletocera aegmiusalis*.

2. Talanga sexpunctalis

Moore (Figs. 2, 18)

Male–Uncus long and tubular, swollen at the apex, bearing tubercles and short hairs. Tegumen bulged out in the middle. Gnathos with slender and pointed median arms. Vinculum narrow; saccus short with a large flat process. Valvae short, ovate; costa and sacculus with sclerotized patches; Clasper composed of a stout sub–apical spine.

Phallus very long with an anterior swollen part and a tail–like posterior part. Cornuti composed of two selerotized thread–like processess running longitudinally.

Female–Bursa globular; signum composed of two round processess covered with short spines. Ductus very long, narrow and coiled. Apophyses long, slender and more or less of the same size. Ovipositor long with swollen ovipositor lobes.

3. Piletocera aegmiusalis

Walker (Figs. 3, 19)

Male–Uncus bifid with two round processes covered with patches of short hairs. Tegumen with two long sheath–like processes posteriorly. Saccus U-shaped with a slight median protuberance. Valvae short and broad, clasper composed of a stout sclerotized pointed patch at about the middle of the valva. Batches of long thick hairs present on the valva at different places.

Phallus is long and stout, slightly curved at the proximal part. Cornuti composed of a longitudinal patch of short spines at the distal end.

Female–Bursa globular with a circular patch of short spines. Ductus short and swollen basally, a short duct of the receptaculum seminis opens into it at about the middle. Anterior apophyses about double the length of the posterior. Ovipositor short with narrow ovipositor lobes.

4. Piletocera chrysorycta

Meyrick (Figs. 4, 20)

Male–Uncus long and rod–like with two subapical lateral processes covered with hairs. Tegumen and vinculum with narrow lateral arms. Saccus U-shaped and large. Valvae short and oval. Cucullus with a tuft of dense hairs. Costa and sacculus with narrow sclerotized patches.

Phallus short and slender, curved in the middle. Cornuti composed of a batch of spines and a transverse sclerotized patch at the distal end of phallus.

Female–Bursa globular, large, with a small diverticulum, the two being separated by means of a constriction. The diverticulum contains two long and two small sclerotized patches forming the signum. Ductus short and swollen. A short duct of the receptaculum seminis opens into the ductus at its posterior end. Apophyses feeble. Ovipositor short with narrow ovipositor lobes.

5. Mabra eryxalis Walker (Figs. 5, 21)

Male–Uncus long and rod-like. Tegumen narrow and long. Vinculum broad; saccus short and V-shaped with a median blunt lobe. Valvae short and broad, narrow at the apex. Costa with a basal curved and inwardly directed process. A long slender lobe arises from about the middle of the valva. Sacculus expanded into a broad flap fringed with hairs. At about the middle of the valva, it bears a short lobe and another triangular lobe bearing tufts of hairs. It ends in a short subapical lobe bearing a tuft of hairs.
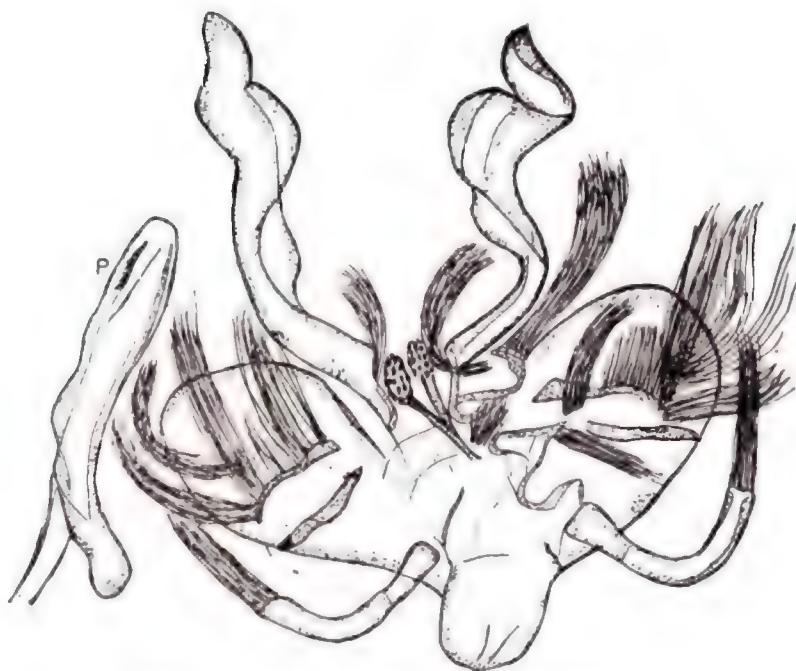
Fig. 4. Male genitalia of *P. chrysorycta.*
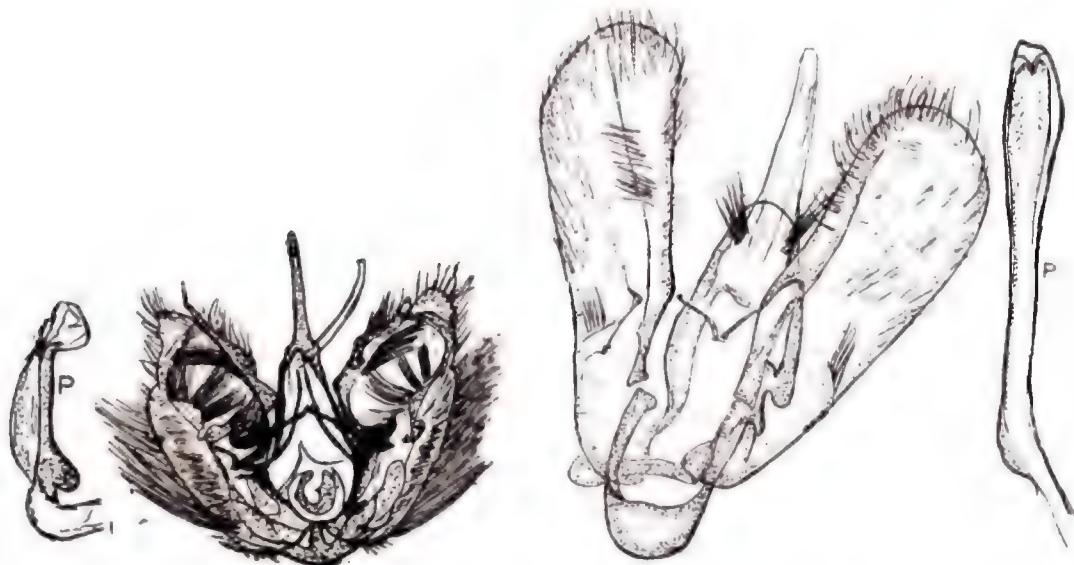

Fig. 5. Male genitalia of *Mabra eryxalis.*
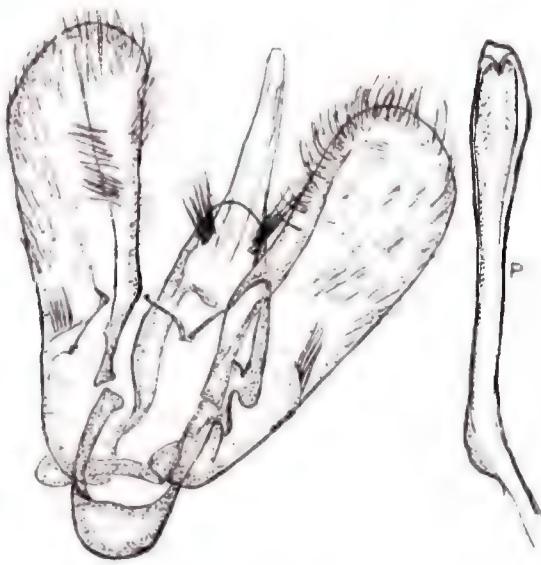
Fig. 6. Male genitalia of *Rehimena phrynealis.*

Phallus short, swollen in the middle and round at the proximal end. A marginal distally pointed, sclerotized patch runs along the whole length of the phallus.

Female–Bursa very long and tubular, basally produced into a slight caecum. An oval receptaculum seminis opens into the bursa a little above its base. Ductus short with rows of spinules at the posterior end. Anterior apophyses about double the posterior. Ovipositor short with narrow ovipositor lobes.

6 Rehimena phrynealis Walker (Fig. 6)

Male–Uncus short, broad and ligulate with lateral tufts of hairs. Tegumen longer than the vinculum. Saccus massive and U-shaped, with narrow lateral arms. Valvae broad and long. Costa with a sclerotized patch. At about 1/3rd distance from the base, the sacculus bears a short process fringed with hairs and with teeth–like projections.

Phallus long and slender, distally broadened.

7. Hymenia recurvalis
                    Fabricius (Figs. 7, 22)

Male–Uucus short, blunt at the tip, fringed with hairs and triangular in outline. Tegumen broad. Vinculum with the saccus U-shaped and having a slight conical process on it. Valvae narrow at the base and with flap-like expansions. Costa with a sclerotized patch extending as far as the apex; a finger–like lobe at about its middle and another basal sclerotized patch which is apically tufted, Clasper composed of two oppositely placed spines, one borne on the basal portion of the costa and the other on the sacculus.

Phallus long, pointed. Cornuti composed of a long process, broad distally and thread-like posteriorly.

Female–Bursa elongate oval, narrowed besally where it receives the duct of the receptaculum seminis. Signum composed of an oval body with one half portion covered with transverse rows of spinules. Ductus short and dilated postariorly. Anterior apophyses long, about, twice the length of the posterior and basally broadened. Ovipositor short with broad ovipositor lobes.

8. Agrotera basinotata Walker (Fig. 8)

Male–Uncus conical and pointed. Tegumen bearing a tuft of long hairs cephalad on either side. Valvae oval with an acute tip. Costa and sacculus with selerotized patches. Cucullus with a tuft of long hairs.

Phallus long, broadened distally and cleft into lobes.

9. Aetholix flavibasalis Guenee (Fig. 9)

Male–Uncus with lateral tufts of long, broad scale-like processes. Tegumen narrow. Saccus conical with a round process. Valvae long and lanceolate. Costa with an arched sclerotized patch. A little beyond the middle, a short triangular spine along the costa. A median tuft of long hairs from the base of the valva and another at about the middle. The sclerotized patch on the sacculus broad at the base and narrowed afterwards.

Phallus long and slender with a slight subapical bulging. A scobinate patch at the distal end.

10. Ercta ornatalis Duponchel
                    (Figs. 10, 23)

Male–Uncus broad. Tegumen broad, cephalad with a row of very long hairs on either side. Median arm of gnathos long and slender. Vinculum with narrow lateral arms; saccus U-shaped, slender,

Fig. 7. Male genitalia of *Hymenia recurvalis.*

Fig. 8. Male genitalia of *Agrotera basinotata.*

Fig. 9. Male genitalia of *Aetholix flavibasalis*.
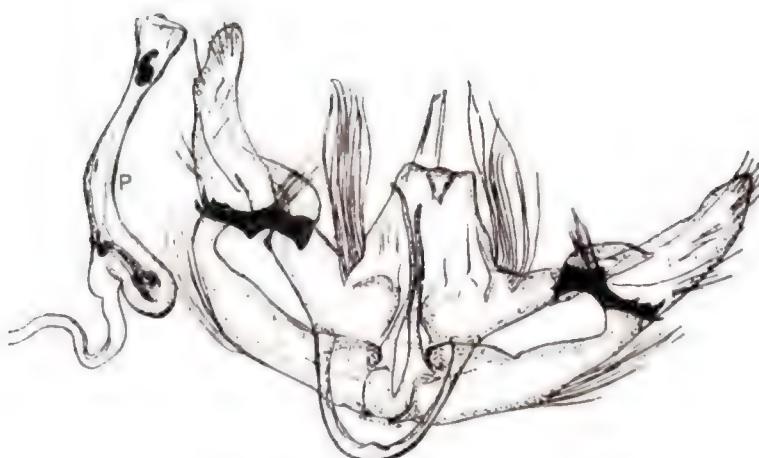
Fig. 10. Male genitalia of *Ercta ornatalis*.

Valvae broad at the base; conically narrowed and finger-like. Costa with a sclerotized patch, which at about the middle bears a stout barbed process forming the clasper. Sclerotization of the sacculus broad basally, narrowed and bent inwards at about the middle of the valva.

Phallus long, curved in the middle, flattened at the apex and round at the proximal end. Cornuti composed of a stout spine curved at its tip.

Female–Bursa long, narrow and tubular. A round accessory sac opens by a short duct into the bursa at its middle. Signum composed of two batches of short spines. Ductus short, dilated at the posterior end. A serrate conical process close to the anterior apophyses. The latter stout in the middle. Ovipositor short with broad ovipositor lobes.

11. Bocchoris inspersalis Zeller
(Figs. 11, 24)

Male–Uncus conical with a short median projection. Tegumen narrow. Vinculum posteriorly V-shaped. Valvae short, oval and slightly bulged out mid-dorsally. Costa and sacculus with sclerotized patches. Cucullus with a tuft of thick hairs.

Phallus long. Cornuti composed of two sclerotized structures, one large and the other small.

Female–Bursa large and globular. Signum composed of a long spine having a crescent–shaped base. Ductus short and broad with a lens-shaped sclerotized body set transversely in the middle. Apophyses slender. Ovipostor short with narrow lobes.

12. Filodes fulvidorsalis Hubner (Fig. 12)
Male–Uncus long and conical. Tegumen broad basally. Vinculum with a broadly V-shaped saccus. Valvae elongate oval. Cucullus with a cluster of broad scales. Costa with a stout spine arising from the base. Another median, stout spine from the base of the valva. Sacculus with a long stout spine at the base.

Phallus long and stout, broad in the middle. Cornuti composed of a stout spine at the distal end, a batch of spines at the middle, and a short patch of spinules proximally.

13. Tyspanodes linealis Moore (Fig. 13)
Male–Uncus long, finger-like and apically narrowed and tufted with hairs. Tegumen short, broadened cephalad. Vinculum posteriorly broadened with narrow lateral arms. Saccus U-shaped. Valvae narrow at the base and broad distally and uniformly covered with long hairs.

Phallus long and stout, narrow in the middle. Cornuti composed of three sclerotized processes, of which one is bare and the others bearing spines.

14. Conogethes suralis Lederer
(Figs. 14, 25)

Male–Uncus thumb-like and apically tufted with short hairs. Tegumen broad cephalad. Vinculum with the saccus large and flat with a slight swelling. Valvae short, bulged out in the middle with the apex more or less flat. Costa with a narrow sclerotized bar.

Phallus long and stout and posteriorly narrowed. Cornuti composed of two arcuate processes at the distal end and a finger-shaped sclerotized patch.

Female–Bursa very long and tubular, composed of a distal swollen part and a proximal tubular part. Ductus short and narrow. Anterior apophyses longer than the posterior which are short and feeble. Ovipositor and lobes narrow.
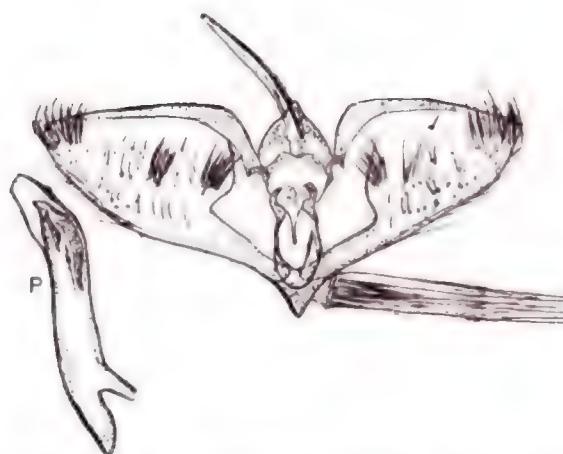
Fig. 11. Male genitalia of *Bocchoris inspersalis*.
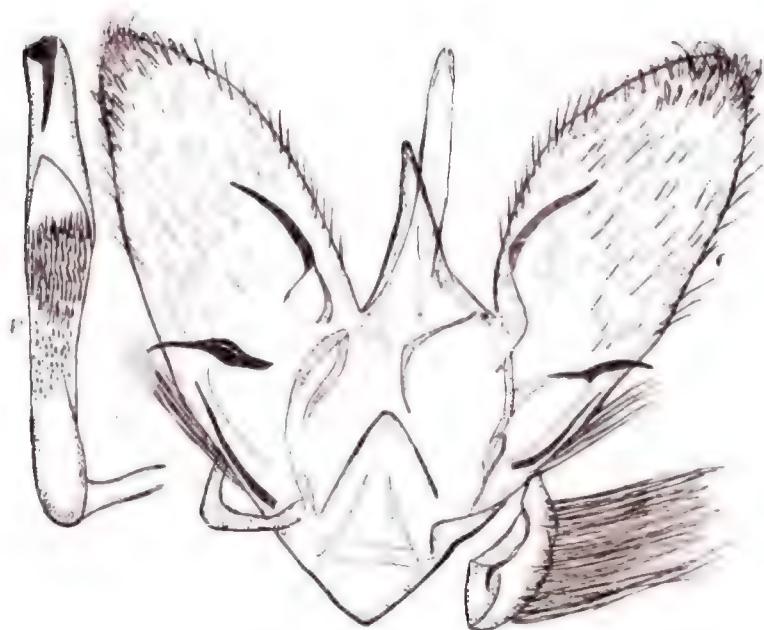
Fig. 12. Male genitalia of *Filodes fulvidorsalis*.
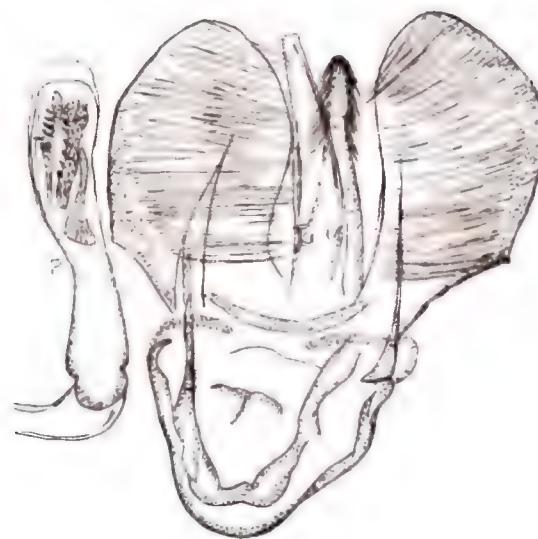
Fig. 13. Male genitila of *Tyspanodes linealis*.
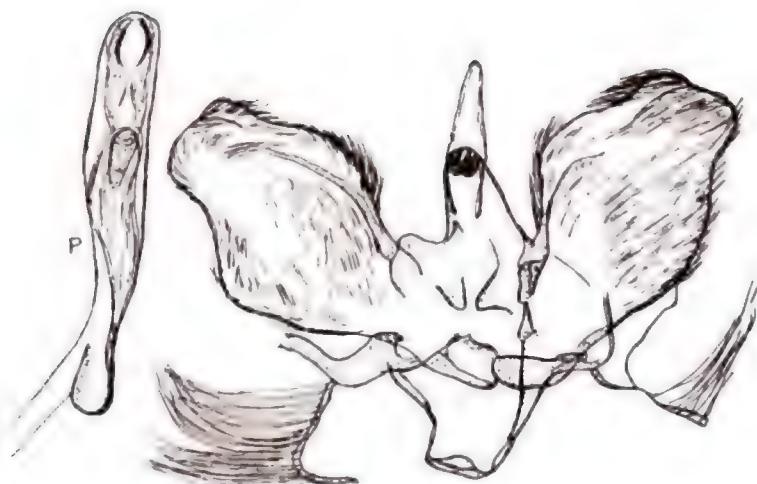
Fig. 14. Male genitila of *Conogethes suralis*.
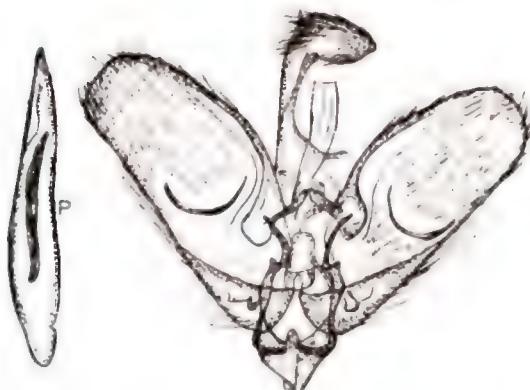
Fig. 15. Male genitalia of *Lamprosema diemenalis*.
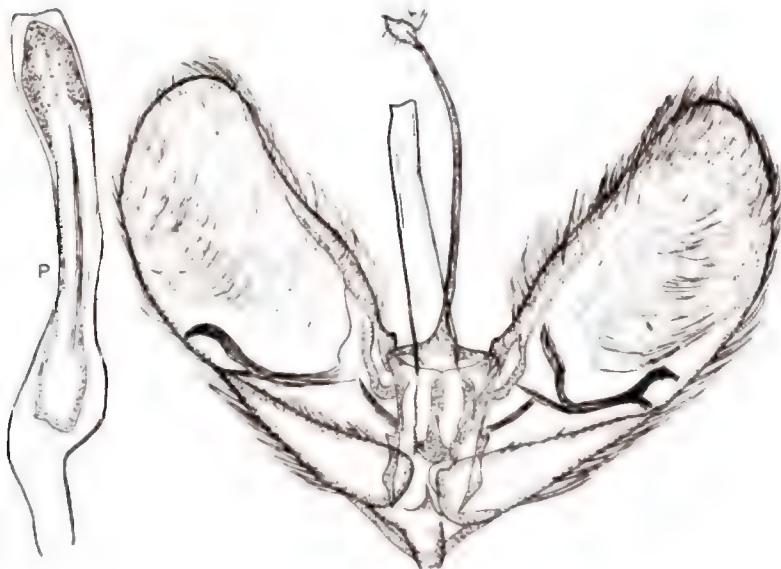
Fig. 16. Male genitalia of *Agathodcs ostentalis*.

15. Lamprosema diemenalis (Guenee)
(Figs. 15, 26)

Male–Uncus with a swollen apical part fringed with hairs and with a long narrow proximal part. Tegumen short with narrow lateral arms. Vinculum longer than the tegumen with the lateral arms narrow and a large conical posterior part bearing a fingershaped lobe. Valvae broad at the middle. Costa with a narrow basally swollen sclerotized patch; sacculus with a short sclerotized patch broad at the base. Clasper composed of a long, curved spine–like process in the middle of the valva.

Phallus pointed at both ends. Cornuti composed of a long rod-like process.

Female–Bursa globular and the signum composed of a circular patch of spinules. Ductus tubular, narrow and long. Anterior apophyses twice the length of the posterior. Ovipositor short with swollen lobes.

16. Agathodes ostentalis Hubner
(Figs. 16, 27)

Male–Uncus very long and narrow, apically flattened into a lobe and fringed with sparse hairs. Tegumen shorter than broad. Lateral arms of vinculum narrow; saccus broadly U-shaped with a median conical process. Valvae long and broad; costal and saccular sclerotization present, of which the latter is broad at the base. Clasper composed of a stout spine borne on a long, slender, sclerotized patch.

Phallus long, narrow in the middle. Cornuti composed of a long, narrow, distally pointed rod-like structure. Scobinate patches present at the distal end.

Female–Bursa globular, with a short, ovate diverticulum at its base. Ductus narrow, with a short duct of the receptaculum seminis opening into it poseriorly. Apophyses of the same size, feeble. Ovipositor short with narrow ovipositor lobes.

DISCUSSION

Genitalial morphology of 16 species of Pyraustinae belonging to 14 genera were studied here. Modifications of the various parts in the different species are summarised below:

Male genitalia: The valvae appeared broad and oval in outline in most of the species studied. It was narrow at the base in *T. linealis* and *T. sexpunctalis.* Its apex was broad and flat in *C. suralis* and *C. fumipalpis.* *B. inspersalis* and *M. eryxalis* possessed valvae which were roughly triangular in outline.

In most cases valvae were uniformly covered with hairlike setae although variations like partial hairiness, presence of hairs arranged in bundles, presence of short spine–like hairs or scale–like formations etc., were also noticed.

The uncus exhibited several modifications of taxonomic value. This process was quite well developed in most of the species studied, but less pronounced in *B. inspersalis, A. basinotata, H. recurvalis, R. phrynealis* and *F. fulvidorsalis.* The shape also was found to vary, being triangular *(A. basinotata, H. recurvalis* and *F. fulvidorsalis);* tongueshaped *(R. phrynealis);* long and slender *(M. eryxalis);* with a subapical fringe of hairs *(T. linealis);* bearing two subapical processes *(P. chrysorycta);* apically flattened into a lobe *(A. ostentalis* and *C. fumipalpis);* ending in a knob-like process *(L. diemenalis* and *T. sexpunctalis)* or bifid at the apex, each bearing a knob-like process *(P. aegmeusalis).*

The saccus showed variations in the shape and extent of development being very prominent and U-shaped *(T. linealis, E. ornatalis, H. recurvalis, R. phrynealis, M. eryxalis, C. fumipalpis, P. chrysorycta* and *P. aegmeusalis* or short and blunt *(A. ostentalis).*

The phallus appeared long and slender in *A. ostentalis F. fulvidorsalis, A. flavibasalis, H. recurvalis, R. phrynealis* and *C. fumipalpis;* spindle-shaped in *L. diemenalis* and *B. inspersalis;* short and handle-shaped in *C. suralis* and *T. linealis;* apically broadened with cleft lobes in *A. basinotata* and very long and filamentous in *T. sexpunctalis.* The cornuti was very conspicuous in *T. linealis, F. fulvidorsalis, E. ornatalis, P. chrysorycta, P. aegmeusalis* and *C. fumipalpis.*

Fig. 17. Female genitalia
of *Cirrhochrista fumipalpis.*
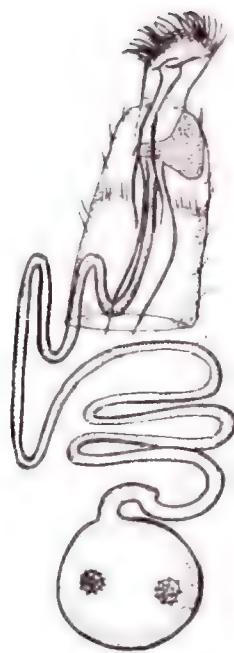
Fig. 18. Female genitalia of
Talanga sexpunctalis.

Fig. 22. Female genitalia of
Hymenia recurvalis.

Fig. 20. Female genitalia of
Piletocera chrysorycta

Fig. 21. Female genitalia of
Mabra eryxalis.

Fig. 19. Female genitalia of
Piletocera aegmiusalis

Fig. 23. Female genitalia of
Ercta ornatalis.

Fig. 24. Female genitalia of
Bocchoris inspersalis.

Fig. 25. Female genitalia of
Conogethes suralis

Fig. 26. Female genitalia of
Lamprosema diemenalis

Fig. 27. Female genitalia of
Agathodes ostentalis.

Female genitalia : In the female genitalia, the bursa and ductus showed several modifications of taxonomic value. The bursa was round with ductus of moderate length in *A. ostentalis, L. diemenalis* and *C. fumipalpis*. The ductus was comparatively shorter in *B. inspersalis, P. chrysorycta* and *P. aegmeusalis.* In *T. sexpunctalis*, the ductus was exceptionally long and coiled. The bursa was very much elongate and tubular *M. eryxalis* and *C. suralis.*

In most species studied, the signum consisted of spine-like processes in the bursa (*L. diemenalis, B. insperalis, E. ornatalis, H. recurvalis, P. aegmeusalis, T. sexpunctalis C. fumipalpis*).

CONCLUSIONS

In the overall morphology of genitalic parts, all the moths studied, showed a general resemblance. Modifications in the structural morphology of uncus in the male genitalia appeared to be useful for segregation of these moths at the generic level while variations in the morphology of other genitalic parts like valvae, phallus, saccus and bursa were useful for specific determination. The species *B. inspersalis, A. basinotata, H. recurvalis* and *F. fulvidorsalis* resembled each other in possessing a short uncus which was usually broad at the base. All the remaining species possessed very much elongate and slender uncus. The following key based on genitalial characters has been prepared for the separation of these insects and is presented below:

1 Uncus short, low, usually broader than long...2
  Uncus elongate and more slender.............4
—Uncus conical or triangualr in outline.......3
  Uncus tongue-shaped, with a prominant tuft of hairs on either side. Saccus broad, U-shaped with the base remaining broader than the sides................*Rehimena phrynealis*

—Uncus flat at the apex. Valvae laterally compressed with a stout transvers, spinuous process in the middle. Ductus with a tubular diverticulum with several spine-like processes forming the signum.................. ....*Ercta ornatalis*

2 Uncus with a short row of small hairs at the apex. Valvae produced basally into flap-like expansions and with 2 spines, one placed opposite to the other...................... ....*Hymenia recurvalis*

—Valvae apically pointed and bearing a tuft of long hairs. Another tuft of long hairs at about its base. Phallus with its apex cleft into lobes..............*Agrotera basinotata* Valvae triangular in outline with tufts of hairs at the apex. Saccus V-shaped. Bursa with a long triangular spine-like signum......................*Bocchoris inspersalis*

3 Uncus broad at the base and tapering to a bluntly pointed apex...........................5

—Uncus long and slender............................6

4 Apical part of uncus with a tuft of short hairs. Valva apically broad and bulged out in the middle. Saccus U-shaped with narrow arms. Bursa elongate and tubular ....*Conogethes suralis*

—Apical part of uncus covered with forwardly directed hairs. Valvae narrow basally and uniformly covered with long hairs. Phallus with 2 stout spiny processes ....*Tyspanodes linealis*
—Apical part of uncus more pointed. Valva with an apical stout spine-like process. Phallus with a stout spine and a cluster of spinules.....................*Filodes fulvidorsalis*

5 Apex of uncus expanded into a lobe........7

—Apex of uncus not expanded.................10
6 Apex of uncus bifid, each ending in short hairs.

—Valva with several tufts of long hairs..... ....*Piletocera aegmiusalis*

  Apex of uncus ending in a flattened lobe......8

  Apex of uncus ending in an ovoid process...9

7 Valvae elongate, oval in outline with a tuft of hairs srising from about the middle on the outer margin....................... ....*Agathodes ostentalis*

—Valva compressed in the antero-medial plane, broad apically. Phallus with 2 rod-like processes forming the cornuti............ ....*Cirrhochrista fumipalpis*

8 Apical knob of uncus beset with short fine hairs. Phallus spindle-shaped. Bursa with several concentric rows of spine-like processes forming the signum.................. ....*Lamprosema diemenalis*

—Apical knob of uncus fringed with short hairs arranged in rows. Valva with a stout spine. Phallus and ductus bursa exceptionally very long...*Talanga sexpunctalis*

9. Uncus bare. Valvae short with knob-like processes bearing tufts of hairs. Phallus short and curved. Bursa elongate and tubular with a diverticulum at its base... ....*Mabra eryxalis*

Uncus with a subapical fringe of flattened hairs. Valvae elongate, apically pointed with a prominent tuft of long hairs arising from about the base................. ....*Aetholix flavibasalis*

Uncus with two subapical curved, hairy processes. Valvae apically tufted with long hairs. Phallus with several teeth-like processes forming the cornuti. Bursa constricted into a diverticulum................ ....*Pilotocera chrysorycta*

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SEX ASSOCIATION IN BISHELLATE COCOONS OF TASAR SILKWORM *ANTHERAEA MYLITTA* DRURY

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Various types of cocoon association are noticed in the tasar silkworm *Antheraea mylitta* Drury so far as the shell, pupa and peduncle are concerned. Close association of the outer shell wall of two individual cocoons is one of such associations which may be called bishellate cocoon. The sex association in the bishellate cocoons revealed that male-female association was more frequent than that of the same sex, the ratio being M-F: M-M: F-F = 52: 30: 18 and the difference between them being highly significant. The male-male association was also more frequent than the female-female association. Moreover, the overall occurrence of male was more frequent than female.

(Key words: tasar silkworm, *Antheraea mylitta,* bishellate cocoon, sex association)

INTRODUCTION

Cocoon with single pupa is the usual phenomenon in all sericigenous insects. But different types of association among pupae, cocoon shells and peduncles are noticed in tasar silkworm *Antheraea mylitta* Drury. Close contact of the outer shell wall of two individual cocoons is one of such associations which may be called bishellate cocoon (Nayak *et al* 1987). Sex association in double cocoons has been studied in *Bombyx mori* L. by Rao & Rao (1961) Kumararaj (1968), Tayade (1982–1983), Narayana Prakash *et al.* (1984) and Govindan & Narayana-swamy (1985); in *Philosamia ricini* H. and *A. assama* W. by Talukdar (1961) and in *A. mylitta* by Saxena & Bhide (1969) and Nayak *et al* (1986). But there is no such study on sex association in bishellate cocoons. As such in this investigation, attempts have been made to study the sex association in bishellate cocoons.

MATERIALS AND METHODS

One thousand bishellate cocoons of 'Sukinda' Trivoltine eco-race of *A. mylitta* were collected from different places of Mayurbhanj district, Orissa from third crop during December–January 1985—1986. Cocoons were divided at random into ten samples of one hundred each. They were cut open to study the sex association.

Depending upon the sex association, each sample was again classified into three combinations such as male-male (M-M) female-female (F-F) and male-female (M-F). The data were analysed after arcsin transformation for testing the significance of the three associations.

RESULTS AND DISCUSSION

It was found that male—male (M-M), female-female (F-F) and male-female (M-F) association was 30 ± 1.49, 18 ± 1.63 and 52 ± 1.76 per cent

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Table 1. Sex association in bishellate cocoons of *Antheraea mylitta*.

Sl no. of samples	male-male %	female-female %	male-female %	Total participation	
				male %	female %
1	30.0 (33.21)*	18.0 (25.10)	52.0 (46.15)	56.0 (48.45)	44.0 (41.55)
2	29.0 (32.58)	20.0 (26.84)	51.0 (45.57)	54.5 (47.58)	45.5 (42.42)
3	31.0 (33.83)	19 0 (25.84)	50.0 (45.00)	56.0 (48.45)	44.0 (41.55)
4	30.0 (33.21)	17.0 (24.35)	53.0 (46.72)	56.5 (48.73)	43.5 (41.27)
5	32.0 (34.45)	18.0 (25.10)	50 0 (45.00)	57.0 (49.02)	43.0 (40.98)
6	27.0 (31.31)	21.0 (27.28)	52 0 (46.15)	53.0 (46.72)	47.0 (43.28)
7	30.0 (33.21)	16 0 (23.50)	54.0 (47.29)	57.0 (49.02)	43.0 (40.98)
8	32 0 (34 21)	18.0 (25.10)	50.0 (45.00)	57.0 (49.02)	43.0 (40.98)
9	30.0 (34.21)	17.0 (24.35)	53.0 (46.72)	56.5 (48.73)	43.5 (41.27)
10	29.0 (32.58)	16.0 (23.58)	55.0 (47.87)	56.5 (48.73)	43.5 (41 27)
Mean	30.0 (33.20)	18.0 (25.08)	52.0 (46.14)	56.0 (48 45)	44 0 (41.55)
S D	1.49	1.63	1.76	1.29	1.29
SEM ±	0.45	0.49	0.53	0.39	0.39
C D at 5%	1.0				

* Figures in parentheses are angular transformed values.

respectively. Similarly, percentage occurrence of only male was 56 ± 1.29 and that of only female was 44 ± 1.29 (Table 1). Occurrence of M–F association was more frequent than M–M and F–F associations. The overall occurrence of male was more frequent than female.

The difference between the three associations was highly significant. It was also evident from the critical difference that the pairs of association differed significantly. They can be rated as M–F, M–M and F–F in descending order of magnitude (461.47, 332.04 and 250.84 respectively).

Investigation carried out by earlier workers on double cocoons in *B. mori* showed that male–female combination was more frequent than male–male and female–female combination (RAO & RAO, 1961; KUMARRAJ, 1988; NARAYANAPRAKASH *et al*., 1984). TAYADE (1982–1983) found out the overall sex ratio to be contrary to other workers in that the occurrence of male was generally more frequent than female in double cocoons. SAXENA & BHIDE (1969) and NAYAK *et al*. (1986) also made similar observations in *A. mylitta* in that M–F was more frequent than F–F and M–M association showing more females taking part in double cocoon formation than males. But present investigation revealed that though M–F association was more frequent in bishellate cocoons, the overall male population was more frequent than the female.

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BRIEF COMMUNICATION

RELEASES AND RECOVERIES OF AN EXOTIC PREDATORY MITE, *PHYTOSEIULUS PERSIMILIS* (ACARINA : PHYTOSEIIDAE)

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An exotic predatory mite, *Phytoseiulus persimilis* Athias-Henriot was inoculatively released in vegetable crop fields after mass multiplied in the laboratory. Field recovery of this predator suggested that *P. persimilis* could establish on red spider mites of different horticultural crops.

(Key words: Phytoseiulus persimilis, release, recovery)

INTRODUCTION

Of the various natural enemies of red spider mites, *Tetranychus* spp. phytoseiids have been recognised as one of the most valuable groups of predators (CHANT, 1959). Previous studies of MC CLANAHAN (1968) and LAING (1968) on *Phytoseiulus persimilis* Athias–Henriot showed that this predator is extremely predacious and also has a high reproductive rate as compared to other species of phytoseiid mites studied to date. Therefore, under All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds, the predator *P. persimilis* was imported for trials against red spider mites of horticultural crops in 1983. Efforts were made to inoculatively release in the field for establishment of *P. persimilis* on red spider mites attacking vegetable crops and the results are furnished in this paper.

MATERIALS AND METHODS

Culturing and collection

The predator *P. persimilis* was mass reared on two‑spotted red spider mite, *Tetranychus*

Contribution No. 65/87 of IIHR, Bangalore-89.

urticae (Koch) and carmine spider mite, *T. cinnabarinus* (Boisd.) (Acarina : Tetranychidae) as described by KRISHNAMOORTHY (1982) with a modification that instead of a glass plate, a wet cotton swab was spread over the wooden platform and an excised lima bean *(Phaseolus lunatus* L.) leaf (abaxial surface facing top) was held in the centre with a strip of cotton wool all around. The prey, *T. urticae* was mass reared on potted plants of French beans *(P. vulgaris* L.) cv. 'Arka Komal' held in the glasshouse.

Excised lima bean leaves containing all stages of predatory mite with the host mite were removed from culture chamber and held in an air–tight plastic container. A layer of tissue paper was provided all around inner surface of plastic container to absorb moisture from the container in transit. Plastic lids were sealed with cellophane tape to prevent any possible escape of predator.

Releases and recoveries

Farmer's fields where spider mite incidence was observed were chosen for releases. Excised leaves containing predatory mites in the container were removed and stappled on the mite infested leaves at random in the field in the evening.

A total of 371 individuals of predator were released in okra field in March for establishment against the population of red

TABLE 1. Details of inoculative releases and recoveries of *Phytoseiulus persimilis*

Place & month of release	No. & stage of release			Crop & its age when first released	Level of spider mite infestation	Recovery	No. & stae of predator recovered			Mean populat- ion recovered/ leaf
	E	N	A				E	N	A	
SHIVAKOTE										
March '86	250	64	57	Okra, 20 days	Severe	April '86	7	10	1	0.18
						May '86	18	2	—	0.20
July '86	170	—	850	Lab–lab 25 days	Severe					
August '86	240	40	40			August '86	13	22	—	0.35
Sept. '86	398	142	88			Sept. '86	10	7	2	0.19

E—Egg, N—Larva + Nymph, A—Adult

spider mite, *T. ludeni* Zacher. Similarly, a total of 1983 individuals of predator were released between July and September in lab-lab field, where spider mite population was severe.

Fairly after a long period of gap, one hundred leaves were collected from the field at random, where *P. persimilis* were released, for microscopic examination. All stages of predator found on the leaf were counted and recorded as the population per leaf.

RESULTS AND DISCUSSION

The details of releases and recoveries are furnished in Table 1. A mean of 0.18 and 0.20 predator population per leaf was obtained when recovery was made after 33 and 36 days respectively after suspension of releases in the first field. The mean predatoty mite population in the second field was 0.35 and 0.19 when recovery was made after 20 and 13 days respectively after suspension of releases. The above recovery results suggested that *P. persimilis* soon after release in the field was able to prey on *T. ludeni* and established. Releases of

more number of eggs than the adults might have resulted in favour of establishment in the field for reasons that the hatched young ones soon settled in the new environment offered.

P. persimilis has been used for the control of red spider mite *T. urticae* (OATMAN *et al.*, 1968, GOULD & VERNON, 1978), *T. cinnabarinus* (BINNS, 1979) and *T. ludeni* (ULLIO, 1983). Horticultural crops are also attacked by many species of red spider mites including above species. *P. persimilis* being a potential predator of red spider mites, there are greater chances for its establishment in the field on different species of red spider mites and act as a better controlling agent. However, unlike in perennial crops, the regular occurrence of the predatory mite in annual crops such as vegetables is doubtful.

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INSECTICIDAL CONTROL OF SOYBEAN STEM MINER, *MELANAGROMYZA SOJAE* (ZEHNTNER)

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The bean stem miner or bean stem fly, *Melanagromyza sojae* (Zehnt.) is a serious pest of soybean at Delhi. Field experiment with three insecticides *viz*, phorate 10 G, monocrotophos 35 EC and quinalphos 45 EC revealed that all the insecticides were effective in reducing significantly the stem tunnelling per cent. Though highest grain yield (19.88 q ha) was obtained by applying phorate at the rate of 2.0 kg ai/ha) at sowing supplemented with two sprayings of monocrotophos (0.05%) 15 and 31 days after sowing, two sprayings of only quinalphos (0.05%) 15 and 31 days after sowing was economical on the basis of cost-benefit ratio.

(*Key words*: stem miner, *Melanagromyza sojae* (Zehnt.), insecticidal control)

INTRODUCTION

The bean stem miner, *Melanagromyza sojae* (Diptera : Agromyzidae) is a serious pest of soybean specially in Madhya Pradesh, Uttar Pradesh and Delhi. The grub of the pest feeds on the pith of stem and devitalises the plants.

Bhattacharya & Rathore (1977) reported endosulfan and quinalphos (0.05% each) in the control of insect pests and yellow mosaic disease of soybean. A field trial was conducted during 1985 to test the efficacy of different insecticides against the soybean stem miner, *M. sojae* and the results are presented in this paper.

MATERIAL AND METHODS

The trial was laid out at the research farm, Indian Agricultural Research Institute, New Delhi in a randomised block design with a plot size of 13.5 m² per treatment, each replicated three times. The susceptible National soybean variety, 'Bragg' was sown on July 30, 1985. Three insecticides *viz*, phorate 10G having three dosages *viz.*, 1.0, 1.5 and 2.0 kg ai/ha, monocrotophos 36 EC, and quinalphos 45 EC (0.05% each) were used for this trial. Phorate was applied in soil furrows before the seeds. Monocrotophos and quinalphos were sprayed with a high volume sprayer to run off level one time (15 days), two times (15 and 31 days) and three times (15, 31 and 49 days) after sowing. There were altogether 10 treatments including the control and 30 plots.

The crop was infested mainly by the stem miner. Hence, observations were recorded against this pest. Ten plants were labelled per plot at random and height of each labelled plant was measured from the base of the plant to the tip of terminal bud at post-flowering period 55 days after sowing. Afterwards these plants were removed and split open with a field knife to record stem infestation caused by maggots of the bean stem miner. The length of the stem and length of the tunnel (Fig. 1) were also measured to calculate stem tunnelling per cent. At harvest, the plants in the central five rows in each plot were harvested for recording grain yield. The percentage increase in yield was calculated by the formula $\frac{T-C}{C} \times 100$ where T stands for yield from

TABLE 1. Effect of different insecticidal treatments on soybean stem miner, *Melanagromyz sojae* (Zehnt.)

	stem miner		Av. plant height (cm)	grain yield		increase in grain yield over control q/ha	percentage avoidable grain loss/increase over control	price of grain saved at the rate of Rs 300 (q/ha) Rs	cost of labour & insecticide/ha Rs	cost-benefit ratio (CBR)
	Av. % infested plant	Av. % stem length travelled		per plot (kg)	per ha (kg)					
Phorate 1.0 kg ai/ha	43.33 (41.15)	23.19 (28.79)	37.90	1.46	16.22	2.67	16.46/ 19.70	801.00	346.00	1:2.31
Phorate 1.5 kg ai/ha	43.33 (41.15)	14.86 (22.71)	38.63	1.69	18.77	5.22	27.81/ 38.52	1566.00	506.00	1:3.09
Phorate 2.0 kg ai/ha	20.00 (26.56)	12.23 (20.44)	39.37	1.76	19.55	6.00	30.69/ 44.28	1800.00	666.00	1:2.70
Phorate 1.5 kg ai/ha + one spray of mono- crotophos (0.05%)	36.66 (37.29)	19.01 (25.84)	37.40	1.66	18.44	4.89	26.51/ 36.09	1467.00	641.36	1:2.28
Phorate 1.5 kg ai/ha + two spray of mono- crotophos (0.05%)	30.00 (33.21)	14.13 (22.06)	38.67	1.79	19.18	6.33	31.84/ 46.71	1819.00	802.73	1:2.36

(Contd.)

1	2	3	4	5	6	7	8	9	10	11
Two sprays of monocrotophos (0.05%)	30.33 (35.40)	18.42 (25.40)	39.10	1.52	16.88	3.33	19.72/ 24.58	999.00	322.73	1:3 06
Three sprays of monocrotophos (0.05%)	30.00 (33.21)	16.71 (24.12)	39.53	1.62	17.99	4.44	24.68/ 32.77	1332.00	484.00	1:2.75
Two sprays of quinalphos (0.05%)	26.66 (31.11)	17.00 (24.35)	41.93	1.55	17.22	3.67	21.31/ 27.08	1101.00	263.52	1:4.17
Three sprays of quinalphos (0.05%)	26.66 (31.11)	11.59 (19.91)	40.06	1.70	18.88	5.33	28.33/ 39.33	1599.00	395.29	1:4.04
Untreated control	83.33 (65.88)	25.24 (30.13)	37.40	1.22	13.55	—	—	—	—	
SE (m) ±	(4 235)	(1.36)	NS	0.88						
C D at 5%	(12.59)	(4.04)		0.25						

The figures in parentheses indicate transformed values = Arc sin $\sqrt{\text{percentage}}$

the treated plot and C from the untreated plot. The percentage of avoidable loss was calculated by the formula $\frac{T-C}{C} \times 100$ (PRADHAN, 1983). The cost benefit ratio (C B R) was determined by dividing the monetary value of increased yield in different insecticidal treatments over that of control by the cost incurred to obtain the increased yield. The data on height of plants, stem tunnelling plant, infestation and grain yield subjected to analysis of variance. The stem tunnelling per cent was converted into angles and 0.5 was added to zero per cent infestation before analysis.

RESULTS AND DISCUSSION

The relative efficacy of the insecticides tested is presented in Table 1. The mean height of plants in all the treatments did not differ significantly from one another. The damage plant per cent in different treatments was different and differences in them were significant. The minimum damage per cent was in phorate treatment applied at the rate of 2.0 kg ai/ha and this treatment was at par with treatments like quinalphos 2 and 3 sprayings, monocrotophos 3 sprayings, phorate 1.5 kg ai/ha plus 2 sprayings of monocrotophos and only monocrotophos 2 sprayings but significantly superior to phorate 1.5 kg ai/ha plus one spraying of monocrotophos, phorate 1.0 and 1.5 kg ai/ha. The percentage stem tunnelling by the pest in different treatments differed significantly. The minimum stem tunnelling per cent was in plots sprayed with quinalphos three times and the maxium was in the untreated control. The three sprayings of

quinalphos was significantly superior to other treatments and was at par with phorate 2 kg ai/ha. The stem tunnelling per cent in the untreated control and in phorate 1 kg ai/ha was at par. The increase in grain yield in different insecticidal treatments over that of untreated control varied between 2.67 and 6.33 q/ha and the per cent of avoidable loss ranged between 16.66 and 31.84, maximum was in the phorate 1.5 kg ai/ha plus two sprayings of monocrotophos and the minimum in the phorate 1.0 kg ai/ha. Based on grain price of Rs. 300/- per quintal the value of increased yield ranged from Rs. 801.00 and Rs. 1899.00. The maximum increase in yield was in phorate 1.5 kg ai/ha plus two sprayings of monocrotophos. But its cost benefit ratio was less as compared to that of phorate 1.5 kg ai/ha. In case of sprayings, the cost benefit ratio was more with two sprayings each of monocrotophos and quinalphos as compared to that of 3 sprayings of these to insecticides even though the three sprayings gave more yield. When the overall effect of different insecticides was considered 2 sprayings of quinalphos (0.05%) proved to be economical than other treatments.

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Statement of ownership and other particulars about ENTOMON

(Form IV, Rule 8 of the Registration of Newspapers (Central) Rules, 1956)

1. Place of publication : Trivandrum
2. Periodicity of publication : Quarterly
3. Printer's name, nationality and address : V. K. Kesava Prabhu, Indian, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, 695 581.
4. Publisher's name, nationality and address : —Do—
5. Editor's name, nationality and address : —Do—
6. Name and address of individual who owns the newspaper : Association for Advancement of Entomology, Department of Zoology, University of Kerala, Kariavattom, Trivandrum – 695 581.

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(Sd./-)

Trivandrum,
March 31, 1988.

Dr. V. K. KESAVA PRABHU
Publisher, *Entomon*

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